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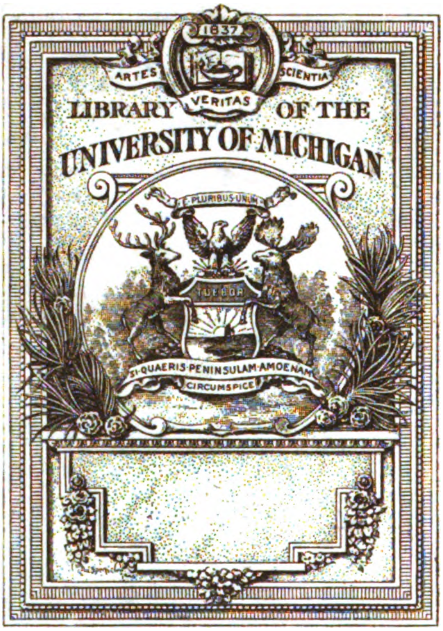

THE GIFT OF
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Station

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University of Vermont and State Agricultural College

Vermont Agricultural Experiment Station

BURLINGTON, VERMONT

TWENTY-NINTH ANNUAL REPORT

1915-1916

BURLINGTON:
Free Press Printing Co.,
1916.

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S. HARGREAVES, Gardener.
C. P. SMITH, LL. D., Treasurer.

---

[1] To September 15, 1915.
[2] From September 1, 1915.
[3] To December 15, 1915.
[4] To May 1, 1916.

☞ Copies of the reports and bulletins of the Station are sent free of charge to any address upon application.

☞ Address all communications concerning station matters not to individual officers but to the Experiment Station, Burlington, Vt. Address inquiries concerning farm practice to Extension Service, Burlington, Vt.

Director's and State Forester's offices, chemical, horticultural and dairy laboratories are in Morrill Hall at the head of Main street; botanical and bacteriological laboratories are at Williams Science Hall, University Place; veterinary laboratories are at 499 Main street.

University farm and buildings are on the Williston road, adjoining the University grounds on the east.

ANNOUNCEMENT

The Vermont Agricultural Experiment Station is organized under an act of the General Assembly of 1886 and acts of Congress approved March 2, 1887, and March 16, 1906. Subsequent state legislation has placed upon the Station the duties pertaining to: (1) the inspection of commercial fertilizers; (2) the inspection of commercial feeding stuffs; (3) the inspection and certification of Babcock glassware and operatives; (4) the inspection of agricultural seed. Its financial support is derived from congressional funds; from state appropriations for report printing and for feeding stuffs and agricultural seed inspection; and from fees from commercial fertilizer manufacturers.

The Station is prepared:

1. To analyze fertilizers, feeding stuffs for domestic animals, seeds, milk and other dairy products, soils (for acidity only), and agricultural materials and products in general, when the results of such analyses are deemed to be of public benefit.

The Station is *not* prepared:

1. To identify fruits, grasses, weeds and other plants, fungus diseases, insect pests, etc., or to advise and assist by correspondence touching matters pertaining to agriculture, horticulture, plant or animal diseases, insect injuries, etc. The service of this character which the Station for nearly 25 years has gratuitously rendered is now performed by the Agricultural Extension Service of the College of Agriculture.

2. To identify or analyze minerals, drinking water, human food or drugs. Minerals should be sent to the State Geologist, Burlington. Waters, human foods, drugs and poison cases should be referred to the State Board of Health Laboratory, Burlington.

3. To test milk and cream regularly and in a wholesale way for any individual or company.

Instructions for taking samples of fertilizers, feedings stuffs, milks and creams, seeds, soils, etc., will be sent on application. Parties desiring to send samples should first write for these directions. Many samples received are useless, being incorrectly drawn. The carriage charges on parcels sent by mail or express should be fully prepaid and they should bear the address of the shipper for purposes of identification.

Vermont. Agricultural Experiment Station 1-16-19

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FINANCIAL REPORTS FOR THE FISCAL YEAR ENDING

June 30, 1916

FOR THE HATCH AND ADAMS FUNDS

Vermont Agricultural Experiment Station, in account with the United States Appropriations, 1915-1916.

DR.

		Hatch	*Adams*
To receipts from the Treasurer of the United States, as per appropriation for fiscal year ending June 30, 1916, as per acts of Congress approved March 2, 1887, and March 16, 1906		$15,000 00	$15,000 00
By	Salaries	$ 8,623 03	$ 9,709 39
"	Labor	1,924 65	2,562 16
"	Publications	296 44	....
"	Postage and stationery	280 33	48 81
"	Freight and express	89 11	14 21
"	Heat, light, water and power	813 42	....
"	Chemicals and laboratory supplies	203 24	343 26
"	Seeds, plants and sundry supplies	254 63	202 20
"	Fertilizers	222 36	1 88
"	Feeding stuffs	877 87	1,440 09
"	Library	38 60	14 24
"	Tools, machinery and appliances	20 78	52 88
"	Furniture and fixtures	21 23	26 09
"	Scientific apparatus and specimens	76 91	201 56
"	Live stock	459 10	4 40
"	Traveling expenses	488 43	317 12
"	Contingent expenses	20 00	......
"	Buildings and land	289 87	61 71
		$15,000 00	$15,000 00

We, the undersigned, duly appointed auditors of the corporation, do hereby certify that we have examined the books and accounts of the Vermont Agricultural Experiment Station for the fiscal year ending June 30, 1916; that we have found the same well kept and classified as above, and that the receipts for the year from the treasurer of the United States are shown to have been on the Hatch fund $15,000, and on the Adams fund $15,000, and the corresponding disbursements on the Hatch fund $15,000, and on the Adams fund $15,000, for all of which proper vouchers are on file and have been by us examined and found correct.

And we further certify that the expenditures have been solely for the purposes set forth in the acts of Congress approved March 2, 1887, and March 16, 1906.

Signed,

GUY POTTER BENTON, } Auditors.
NEWMAN K. CHAFFEE, }

[SEAL]
Attest,
C. P. SMITH, Custodian.

FOR THE FERTILIZER CONTROL, FEEDING STUFFS INSPECTION, AGRICULTURAL SEED INSPECTION AND CREAMERY INSPECTION FUNDS

Receipts and disbursements under Sections 4973-4982, 4989-4993, Public Statutes (fertilizer law); Sections 4983-4993, Public Statutes (feeding stuffs law); No. 184 of Acts of 1912 (agricultural seed law); Sections 4940-4942, Public Statutes (creamery inspection law); for the fiscal year ending June 30, 1916.

To license fees for 1916 received from fertilizer companies.		$3,095 00
To state appropriation for feeding stuffs		500 00
To state appropriation for agricultural seed inspection..	$ 500 00	
To fees for agricultural seed analyses	43 50	
		$ 543 50
To balance on hand last report (creamery inspection) ..	$ 18 01	
To receipts from applicants for licenses	53 00	
To receipts for testing Babcock glassware	197 89	
		$ 268 90

	Fertilizer control	Feeding stuffs inspection	Agricultural seed inspection	Creamery inspection
By Salaries	$1,208 34	$ 282 69	$ 258 33	$ ....
" Labor	216 32	27 05	87 78	238 48
" Publications	28 72	....	28 72	....
" Postage and stationery	24 77	6 70	33 15	4 50
" Freight and express	19 04	6 57	0 26	3 61
" Heat, light, water and power	52 97	....	....	....
" Chemicals and laboratory supplies .	192 05	....	....	....
" Sundries	19 50	....	3 00	6 45
" Traveling expenses	772 42	176 99	118 58	....
" Buildings and land.	4 26	....	....	....
Unexpended balance ...	556 61	....	13 68	15 86
	$3,095 00	$ 500 00	$ 543 50	$ 268 90

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REPORT OF THE DIRECTOR

JOSEPH L. HILLS

The present report covers the work of the Station during the fiscal year July 1, 1915 to June 30, 1916.

PUBLICATIONS

Eight bulletins, one circular and the current annual report aggregating about 750 pages of printed matter, have been issued during the year, the bulletins in editions of 16,000 (save Nos. 193, 195 and 196, technical bulletins issued in smaller edition), the report in an edition of 1,000. A list of publications issued during the year, other than the report, follows:

November.	No. 191.	The Red Rot of Conifers, by F. H. Abbott—20 pages.
December.	Circular 10.	Concerning the Use of Commercial Fertilizers in 1916, by J. L. Hills—16 pages.
February.	No. 192.	Agricultural Seed, by G. P. Burns—40 pages.
February.	No. 193.	Studies in Tolerance of New England Forest Trees; III. Discontinuous Light in Forests, by G. P. Burns—24 pages.
	No. 194.	The Trees of Vermont, by G. P. Burns and C. H. Otis—240 pages.
	No. 195.	Studies of the Values of Different Grades of Milk in Infant Feeding, by R. M. Washburn and C. H. Jones—144 pages.
	No. 196.	Some Studies of Bordeaux Mixture, by B. F. Lutman—80 pages.
May.	No. 197.	Commercial Feeding Stuffs, by J. L. Hills, C. H. Jones and G. F. Anderson. Concerning the Oat Crop, by J. L. Hills—72 pages.
June.	No. 198.	Commercial Fertilizers, by J. L. Hills, C. H. Jones and G. F. Anderson. Concerning Tillage, by R. T. Burdick—84 pages.

The more technical publications are issued in editions of small size, the more popular bulletins in larger editions. Only one set by number is issued, notice usually being given on the title page of the more popular issues of the existence and nature of technical numbers not generally distributed. The report consists of general business statements together with reprints of the bulletins of the year, bound together.

CHANGES IN THE STATION STAFF

A. A. Borland, M. S., Animal and Dairy Husbandman, resigned September 15 to return to his native state, Pennsylvania, to engage in extension work, and G. F. E. Story, B. S., of the Massachusetts Extension Service, a former University of Vermont student, was secured in his place. Messrs. C. G. Williamson and E. L. Baker, respectively Assistant Chemist and Computer, severed their station connections during the year. No successors were appointed.

THE USES OF THE SEVERAL STATION FUNDS

Hatch fund (Federal): "To conduct original researches or verify experiments"; the publication and distribution of the results of station work; administrative work.

Adams fund (Federal): "Only in paying the necessary expenses of conducting original research or experiments."

Neither of these funds can be used in indicating the application of research work save by bulletin publication or correspondence, but are employed simply in making the research which lies back of its application. The latter is now provided for in the Agricultural Extension Service. The Adams fund in particular is hedged about by restrictions and used strictly for research.

Fertilizer control fund (License fees for commercial fertilizers): Solely in the collection and analysis of samples of commercial fertilizers and the publication of the results of analysis, together with additional information bearing upon soils, fertilizers and soil management. The unused residues revert to the state treasury and have done so for several years. They now amount to a considerable sum.

Feeding stuffs inspection fund (State appropriation, $500): Solely in the collection and analysis of samples of commercial feeding stuffs and the publication of results of analyses, together with additional information bearing upon feeds and feeding.

Agricultural seed inspection fund (State appropriation, $500; fees): Solely in the collection and analysis of samples of agricultural seed and the publication of the results of analyses, together with additional information bearing upon seed and its use.

Creamery inspection fund (License fees, etc.): Solely in determining the ability of test operators and the accuracy of Babcock glassware.

Report printing fund (State appropriation, not to exceed $1,000): For printing the annual report.

HATCH AND ADAMS PROJECTS

The following Hatch fund projects have been in hand during the past year:

I, II, III, XII. Administration.

IV. Eccentric growth; tree temperature studies (Botany).

V. (1) Soil studies; (2) Work for other station departments; (3) Free analytical work in accordance with P. S. 352 (Chemistry).

VI. Forest reproduction; permanent sample plot work (Forestry).

VI. Hardwood factor studies (Forestry).

VIII. Quality and quantity studies with Hubbard squash (Horticulture).

IX. Strawberry runner selection (Horticulture).

X. Cion selection (Horticulture).

XI. Cherry graftage (Horticulture).

XIII. Club-root of cabbage and allied plants (Plant pathology).

XIV. Effect of digestive fluids on spore viability (Plant pathology).

XV. Infectious bovine abortion (Veterinary science).

The following Adams fund projects have been in hand during the past year:

I. Forcing plants with carbon dioxid; begun in 1909. (Horticulture).

IV. Studies regarding the nutritive value of milk, its suitability for food for children and animals, conditions which affect its nutritive value, related questions; begun in 1906. (Dairying; chemistry).

V. Effect of feeding different amounts of digestible protein to cows for a long period; begun in 1906. (Dairying; chemistry).

VI. Study of fundamental processes relative to the storage of sugars and other carbohydrates in wood and in the bark of the sugar maple, brown ash, birch, beech, oak, pine and apple; begun in 1909. (Chemistry; forestry).

VII. Maintenance rations for dairy cows, proportions of nutrients used; (a) maintenance, (b) in foetus construction, (c) in milk formation; begun in 1906. (Dairying).

VIII. Stimulating effect of bordeaux mixture on plants, especially the potato plant; begun in 1909. (Plant pathology).

IX. The effect of age and climatic conditions upon the efficiency of bordeaux mixture and other fungicides as shown by the inhibitory effect upon the germination of spores; begun in 1910. (Plant pathology).

X. The potato scab; a study of immunity of the advance of the disease during the growth of tubers, etc., the relation of the effects of various chemicals; etc.; begun in 1909. (Plant pathology).

XI. The tolerance of forest trees; begun in 1911. (Forestry; botany).

XII. The damping off of seedlings due to fusariums and other organisms; begun in 1908. (Plant pathology).

XIII. Plant breeding studies with *Violoceae* and *Rubus;* begun in 1913. (Botany).

XIV. Sterility of strawberries; begun in 1914 (Horticulture).

XV. Blood complement studies; begun in 1915. (Veterinary science).

THE FREE ANALYSIS PRIVILEGE

Section 352 P. S. requires the Station to make free analyses of agricultural materials for residents of Vermont. The statutes omit to make any appropriation to the Station for doing this work. The calls made upon the Station under this statute are rapidly increasing. There were 798 such free analyses made in the fiscal year of 1911, during the fiscal year which closed a year ago and during the past fiscal year almost 2,500, a four fold increase within five years. It was said in last year's report that "this increase is due to many factors. The parcel post makes it easier and cheaper to send packages nowadays than formerly; the county agents have aroused popular interest and have informed the farmers as to the existence of the privilege; certain feed dealers thus use the Station in connection with a very shewd advertising scheme which serves to put money into their pockets; great interest is being aroused in connection with the use of lime on soils; and there are other reasons. The burden of this work is becoming heavy. It is a question whether the Station can carry on this work indefinitely if it continues to increase, without assessing its cost upon those who send the samples, as is generally done by the stations in other states which receive no state appropriation."

In view of this situation the Trustees in their forthcoming report to the next General Assembly have asked that this work be supported by direct appropriation.

DEPARTMENT REPORTS

The following concise statements indicate something of the scope of the work which has been in hand during the past fiscal year:

ANIMAL HUSBANDRY

The department has been concerned during the past year with the prosecution of the following projects:

1. *The feeding trials in which varying amounts of protein are fed* either continuously or alternately for long periods of time, beginning in 1906, and vigorously pushed throughout the year, were modified in 1914 so as to include a very low protein ration. The immense amount of data now in hand has been collated and bulletin publication during the coming year is confidently expected.

2. *The maintenance requirements of dairy cows* are being studied to determine the nutrients necessary for (a) body maintenance, (b) foetal development, (c) milk production, (d) foetal development and milk production. Representative cows in considerable numbers are being used and data are slowly accumulating.

3. *The metabolic requirements of dry cows* which alternately gain and lose in weight between wide limits are being studied and interesting data are being accumulated. The trial has been under way for some years and has been enlarged recently with a view of minimizing possible error due to personal equation.

4. *The nutritive values of milk in the feeding of the human young* has been under review for many years and a bulletin (No. 195) has just been issued. The trials were completed some years ago but the manuscript could not be prepared until recently. Further studies along these lines will be inaugurated, beginning August 1, 1916.

ADVANCED REGISTRY

The Station, acting in accordance with the rules adopted by the Ayrshire, Brown Swiss, Guernsey, Holstein-Friesian and Jersey Breeders' Associations, exercises oversight and vouches for the accuracy of advanced registry records. This work is extra-legal in that it is not, as is all other work done by the Station, prescribed by state or by federal law. The Station acts for the breeders at their request. The work, being done for private individuals, is financed by them. Incidentally it has public relationships, in that anything which may be done to enhance the value of the dairy stock in a sense is work done in the interests of good dairying throughout Vermont.

The volume of this work is now quite large and is well systematized.

Five years ago 16 breeders thus made use of the Station, whereas this year 102 Vermont breeders have secured advanced registry records. Less than 600 test-day records were made during the fiscal year of 1910-11, whereas more than 3,580 were made the past year.

A large part of the work is done in three southern counties, Windham, Windsor and Rutland, and almost all of it in these three together with Caledonia, Franklin, Lamoille and Washington counties. There seems to be some relationship existing between the activity of the county fairs and advanced registry work. There is a live fair organization in each of these seven counties, whereas in but one of the counties in which little or advanced registry work has been done is there a large fair.

The following condensed statement sets forth the work done during the past year.

Ayrshire. Eight breeders have had 116 cows on semi-official yearly tests, with a total of 496 tests for 992 days.

Brown Swiss. One breeder has had 5 cows on test with a total of 11 tests for 22 days.

Guernsey. Four breeders have had 25 cows on semi-official tests, with a total of 139 tests for 276 days.

Holstein-Friesian. Sixty-seven breeders have had 359 cows tested for 2,780 days. Twenty-two of these cows were on semi-official yearly test with a total of 73 tests for 147 days and were tested for 14 days, three for 20 days, one for 25 days, four for 30 and two for 60 days.

Jersey. Twenty-two breeders have had 277 cows on test for a total of 1,544 tests for 3,088 days, all being semi-official yearly tests.

Financial Statement Advanced Registry July 1, 1915—June 30, 1916.

RECEIPTS

Cash on hand July 1, 1915	$ 240 80
Official test fees	5,521 55
	$ 5,762 35

DISBURSEMENTS

Salaries	$ 710 04
Labor	4,007 00
Postage and stationery, telephone and telegraph	132 37
Freight and express	14 08
Chemicals and laboratory supplies	42 61
Sundry supplies	34 15
Furniture and fixtures	8 05
Travel (supervisors)	483 96
Travel (official)	57 68
	$ 5,489 94

ASSETS.

Receipts (as stated above)	$ 5,762 35
Due from breeders (Mar., Apr., May, June)	381 60
	$ 6,143 95

LIABILITIES

Disbursements (as stated above)	$ 5,489 94
Due supervisors	308 84
	$ 5,798 78

Cash on hand June 30, 1916	$ 272 41
Excess amount due from breeders over amount due supervisors	72 76
	$ 345 17

BOTANY

The work in the botanical department has been prosecuted along five lines:

1. *Forest botany tolerance.* The departmental staff has continued the study of tolerance of New England forest trees during the year, devoting its time largely to a study of the conditions best suited to the development of white pine and other seedlings. The physical conditions in the woods under lath shades and under cheese cloth shades were studied, especially during the summer months in continuation of the work of previous years. The third bulletin in this series, No. 193, entitled "Discontinuous Light in Forests" has been published during the year.

2. *Forest botany eccentric growth.* The experimental work carried on to determine the cause of eccentric growth in trees was continued through the year, substituting small white pine and spruce grown in pots in the greenhouse for the larger trees growing in the

open. This change in the method of attacking this problem has been very profitable and significant results have been secured.

3. *Forest reproduction.* The field work on the plots which were cleared and on the adjacent control plots—as described in former reports—has been continued and accurate records made of the changes observed. This work includes many types of forests in Vermont and is carried on in cooperation with the forester.

4. *The storage of starch.* The department is cooperating with the chemical department in the study of starch storage in trees. Many samples have been collected and preserved for future study.

5. *Plant breeding.* Considerable time has been devoted during the past year to the study of sterility among the Vermont forms of blackberries. The almost complete collection of Vermont forms of blackberries which are now growing in the station garden has been utilized. Several methods were employed. It appears that the amount of sterility varies greatly for the different species and hybrids. The significance of this variation in the amount of sterility as indicating the origin of these many forms is being studied. The effect of external factors on the growth and development of the different species of blackberries were studied from plants grown under controlled greenhouse conditions. The F. generation seedlings of the crosses made during the previous year and the seedlings of the natural hybrids were studied in reference to Mendelian characters.

CHEMISTRY

The work for the past year is covered in a general way by the analyses of licensed commercial fertilizers (bulletin 198); commercial feeding stuffs (bulletin 197); analytical work connected with the feeding trials with dairy cows, including roughages, concentrates and milk; and with more than 2,300 miscellaneous analyses of agricultural materials sent in by residents of the State.

1. *Feeding value of milk of different grades in infant feeding.* An extended investigation carried on in connection with the animal husbandry department designed to show the effect on body composition of young pigs resulting from the feeding of milk of different grades measured primarily by their fat content, has been completed and the results have been set forth in bulletin 195 entitled "Studies of the Values of Different Grades of Milk in Infant Feeding."

2. *The availability of the organic nitrogen in commercial fertilizers* has been studied as usual. Brands that show inferiority in this

respect have been studied, the organic portions separated from the inorganic and separately examined, and the original analyses confirmed. Cooperative work on nitrogen was also done for the Association of Official Agricultural Chemists.

3. *Soil studies.* Hundreds of samples from all sections of the State have been examined for lime requirement and organic matter content. The lime requirement was determined by the calcium acetate method, devised at this Station. Most of the samples tested are well supplied with organic matter, a very desirable condition. It seems quite certain that as a rule Vermont soils are quite acid and that the use of lime should be encouraged, particularly when clover and alfalfa are to be grown. While no opportunity has been afforded us closely to follow up the recommendations made on the basis of the calcium acetate test as to the use of lime, yet evidence is at hand which indicates that most satisfactory results have been secured. It seems safe to assert that the method is a practicable one, capable in the hands of a non-expert, a county agent for example, of affording in a few minutes the desired information as to so-called soil acidity conditions. In this connection it may be said that more than a hundred samples of limestone, mostly from Vermont sources, have been examined with a view of determining their suitability for local grinding for agricultural purposes.

4. *Carbon dioxid trials, etc.* Analyses have been made of about one hundred samples of the crops grown by the horticultural department in its carbon dioxid trials, with a view of determining the differences in dry matter, ash, protein and carbohydrate storage. (See horticulture).

5. *The carbohydrate contents of maple and other woods* has been studied as time has permitted.

A total of 4,491 samples has been analyzed as follows:

Milk (station herd)	696
Milk and cream (from private individuals)	1,128
Commercial fertilizers (official)	168
Commercial feeding stuffs (official)	429
Roughages and concentrates (in connection with protein trials)	717
Maple syrups (maple investigations)	36
Wood (carbohydrate storage problem)	20
Commercial feeding stuffs (private individuals)	242
Miscellaneous (from private individuals) including soils	932
Miscellaneous (horticultural and botanical departments)	123
	4,491

INSPECTION WORK

1. *Commercial fertilizers.* Fertilizer control work continues to be an important and popular phase of station endeavor. The writing, printing and distribution of the results of the yearly inspection as well as of the compiled matter dealing with sundry phases of soil management is paid for with fertilizer control funds. In no way whatsoever, directly or indirectly, are the federal funds used for this purpose. One hundred and sixty-eight brands, the output of 18 companies, were analyzed and with a few exceptions were found to be as good as they were said to be.

2. *Commercial feeding stuffs.* The small appropriation for this work, less than that made in any other state, necessitates an inadequate control of this trade. Nearly 700 samples have been drawn and analyzed for protein only. The outcome was a very unsatisfactory one, a large number of feeds being seriously deficient. The Station is able to purvey much general information in its feeding stuff bulletins.

3. *Creamery glassware and operators.* The volume of this line of work has been fairly uniform. Several thousand pieces of Babcock glassware, mostly cream bottles, were tested. The proportion of inaccurate glassware is quite small. A few would-be licensees were unable to pass an adequate examination and licenses were refused.

4. *Agricultural seed.* About 350 samples were collected in 1915 and nearly 500 in 1916. These have been tested, the results appearing in bulletins 192 (1915) and 200 (1916). Guaranties were omitted on one-seventh of the 1915 sales; were not made good in fact in one-twentieth of the samples; and 14 lots of timothy and red top were found to be ergotized.

FORESTRY

The experimental work for the past year has been along two lines.

1. *Permanent sample plot work.* These sample plots have been located in the University woodlot at Burlington, and on the state forests at Plainfield, West Rutland, Proctorsville and Townshend. In each case one or more experimental plots have been established and the check plots to accompany same. The plots are 100 feet square with isolation strips surrounding them. Each tree has been carefully located, the crown mapped in and the circumference measured. On each of the larger plots two or three sub-plots, ten feet square each, have been carefully mapped in order to study reproduction. Each season these sub-plots are carefully resurveyed and the number of

seedlings of every kind of plant which comes into the plot tabulated. In this way we shall be able to formulate some very definite information as to what takes place under different conditions of light, moisture, etc. It is understood that this study is of a permanent nature and that the longer the experiment is continued the more satisfactory will be the results. It may be possible, however, during the coming winter, to issue a preliminary statement of this work.

2. *Hardwood study.* The object of this study is to determine a more efficient and accurate method of estimating old growth hardwoods, especially in culled stands. It has been found that all available volume tables give very unsatisfactory results. The study is following the lines which have been worked out by Scheffel of Germany and Jonson of Sweden. The result will be either volume tables classified not only in height diameter classes, but also form classes, or else mathematical formulas which will enable the estimator to make local volume tables for any particular stand which he may be estimating. Very careful volume measurements are being made of hardwood timber wherever cutting is being done. The volumes, form factors, and form quotients of all of these trees are carefully computed. If possible, mathematical relationship between form factor, form quotient and volume will be determined. If the mathematical law cannot be discovered, these different factors will be arranged in tables so they may be used in that form.

HORTICULTURE

The work of the horticultural department of the past year has been devoted to a further prosecution of the following projects:

1. *Forcing plants with carbon dioxid.* The problem was that of determining the effect of the artificial application of this gas to various horticultural plants. Especial attention this past year has been given to the determination of optimum applications, computations on chemical modifications of treated plants, and preparation of manuscript for publication.

2. *Sterility of strawberries.* Many varieties of strawberries are self-sterile because of their unisexuality. The project called for a study of the causes and remedies of this sexual imperfection. Breeding experiments have started to study the behavior of sexes in crossed and uncrossed progeny. The record generation plants have been secured, and the third generations crosses are being made. Nutrition experiments are also under way with a view of studying the effect of varied feeding upon sex characteristics.

3. *Cion selection.* The study of the effect if any of the selection of cions from parent trees of superior or inferior fruiting habits which was started several years ago has been continued during the past year. Many of the cions are coming to a bearing age and their capabilities are being noted. Increasingly as the years go on this project should bear fruit, both figuratively and literally.

4. *Quality and quantity in Hubbard squash.* A further study has been made of the internal factors that govern quantity and quality in squash. Seed selection work has been continued, using seed from high and low yielding plants of both crossed and uncrossed parents, also from intercrossed specimens. Selections have been made on the basis of quality, particularly with reference to mealiness, wetness and coarseness of the flesh. The ultimate effect of continued self-fertilization is also being determined.

5. *Strawberry runner selection.* This project involves the question of improving the yields of strawberry plants by some method of stolon selection on the basis of parental yields. Earliness or lateness of formation; from one year or two year old plants; high and low yields; abundance and scarcity of stolons formed, are the contrasting factors. A considerable number of plants are under experiment.

PLANT PATHOLOGY

The plant pathology projects which have been in hand during the past year include:

1. *Potato scab.* The study of potato scab has been continued along practically the same lines as in the previous year. A detailed study of the structure of the skin of resistant and susceptible tubers has been made with interesting results.

2. *Effect of bordeaux on fungus spores and on sprayed plants.* A publication on this project has just been issued (bulletin 196). The favorable effect obtained from the use of bordeaux on potato plants seems to lie to a larger extent than has been heretofore appreciated in the prevention of tip-burn and all experimental and observational work on this project has dealt with this phase in the life history of the potato in this climate.

3. *The fusarium wilt of peas and asters.* The resignation of the associate plant pathologist, effective in June, 1915, has prevented much continuous work on this project during the past year; but it is expected that the data which have been secured on the conditions of infection will be made available for publication in the near future.

4. *Club-root of cabbage and allied plants.* This project, having been placed in the charge of the former associate plant pathologist, could not be pushed as vigorously as in previous seasons. However, much additional data as to disease resistance of several varieties of cabbage and other plants and as to the effects of soil treatment are in hand. It is hoped that a final publication dealing with this project can be made during the present year.

VETERINARY SCIENCE

The work of the department for the past year has been confined to the furtherance of the following projects:

1. *The treatment of infectious abortion.* During the first half of the year samples of blood from over 500 cows were subjected to the complement fixation test and over 100 additional reacting cows were treated with methylene blue and cresol. During the last six months owing to war conditions methylene blue could not be obtained in sufficient quantities to enable the completion of this investigation. Methylene blue is made in Germany and now out of the market. It is quoted at $80 a pound, whereas it formally cost but $1.50 a pound.

The period of treatment has been reduced to three weeks, and in all herds where reacting animals have been left untreated to serve as control, there has been a pronounced showing in favor of the treatment. The cows in the treated class which aborted did so during or within two weeks of treatment or not until about three months had elapsed. The abortions which occurred during or within two weeks of treatment are believed to have represented cases which were too far advanced to be controlled and the occasional occurrence of abortion three months or more after treatment is attributable to reinfection.

2. *Improvements in the technique of the complement fixation test.* Improvements in the development and handling of the factors involved in the complement test which have been worked out by this department have been on trial during the past year. A manuscript is now in process of preparation setting forth the nature of the improvement and the results attained by its use.

3. *Control of blood complement.* Breeding experiments have been conducted throughout the year with guinea pigs in which selective mating with reference to complement titration has been practiced. Over 1,300 offspring were produced, the blood of which has been carefully titrated to determine the complement content. Very interesting results have been obtained, but larger numbers of animals will be required to clear up some details of the investigation.

NOVEMBER, 1915 BULLETIN 191

University of Vermont and State Agricultural College

Vermont Agricultural Experiment Station

BURLINGTON, VERMONT

THE RED ROT OF CONIFERS

by F. H. ABBOTT

(Vermont forestry publication 19)

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University farm and buildings are on the Williston road, adjoining the University grounds on the east.

BULLETIN 193: STUDIES IN TOLERANCE OF NEW ENGLAND FOREST TREES

III. DISCONTINUOUS LIGHT IN FORESTS

By George P. Burns

Introduction

At present the only measure of the so-called "tolerance of forest trees" is the appearance of trees as they grow under the influence of the physical and biotic factors of a given habitat. If the trees are developing slowly, they are "intolerant"; if they are developing rapidly, they are "tolerant."

The factors then that determine "tolerance" are the factors of the habitat; and any study of forest succession, whether natural or artificial, requires an analysis of all those factors, of which light is only one. Upon entering the forest, the lowered intensity of the light is strikingly manifest. No other physical factor is so markedly altered. Hence one naturally associates the variation in the forest vegetation with the light conditions. A poorly developed lot of seedlings is supposed to result from the weakened or filtered light under the dominant trees; and the suppressed trees are supposed to be suppressed because of the changed light conditions.

Zon and Graves (16) in a discussion of the relation of light to tree growth have stated admirably the problems of tolerance. They cite literature indicating that many factors other than light influence tolerance. These authors conclude that we are "far from a thorough understanding of the effect of light upon the individual tree and especially on the trees in the forest." Almost every page suggests problems in plant physiology which must be solved and their work is well adapted to "stimulate an interest in further research in determining more accurately the light requirements of our forest trees, especially by measurements of light in the forests."

Fricke (5) dug ditches around certain plots thus relieving the "suppressed" trees growing thereon from the competition which existed between their root-systems and those of the dominant trees. Not only did vigorous young seedling trees grow in these isolated plots, but there also appeared a "luxuriant herbaceous vegetation strikingly different from that in the surrounding forest." The forest cover was not altered and without any change in the light conditions, the suppressed vegetation began a vigorous growth, seeming to indicate that "root competition"was at fault rather than light shortage in cases of suppression. Hartig (8) says that, on a good soil, a given number of leaves will produce more substance than will the same number of leaves on a poor soil. "The growth of a tree may suddenly double or treble without increase in leaf surface or light intensity if the nourishment of the roots is greatly increased." He thus clearly recognizes soil conditions as a limiting factor in the growth of trees.

Tolerance, then, in the strict and proper sense of the term, represents the ability of a tree to thrive under the conditions of soil moisture, light, humidity, etc., found in any given habitat. However, this word is so established in our literature as expressing a light relationship only, that it will be difficult to superimpose the meaning just indicated. A clear understanding of the problem of forest succession and forest reproduction would be more easily attained in all probability if the word were elided from forestry literature.

LIGHT MEASUREMENTS IN FORESTS

The present bulletin attempts to determine the value of "light measurements in the forest" and to determine their significance in a study of the light requirements of our forest trees.

Light reaches the forest floor in four ways, through the tree crowns, between the tree crowns, reflected from leaves and twigs, and through the leaves themselves. The light which passes through the leaves is altered in composition; the rest is white light. Obviously, then, the kind and intensity of light vary greatly in forests of different species of trees.

The study of light intensities in the forests has been made along two distinct lines, according as the workers have emphasized the importance either of weakened white light or of filtered light in forest growth and reproduction and in the development of the vegetation of the forest floor.

FILTERED LIGHT IN FORESTS

Zederbauer (15) made a study of the light which passed through the leaves of several different species of plants and found that there was some variation in the rays absorbed. He argued therefore that the light in the forest must be altered in composition as it passes through the crowns. Accordingly he undertook to study the light in forests with a spectroscope. The stations selected were located in pure stands with the first branches ten meters from the ground and were situated

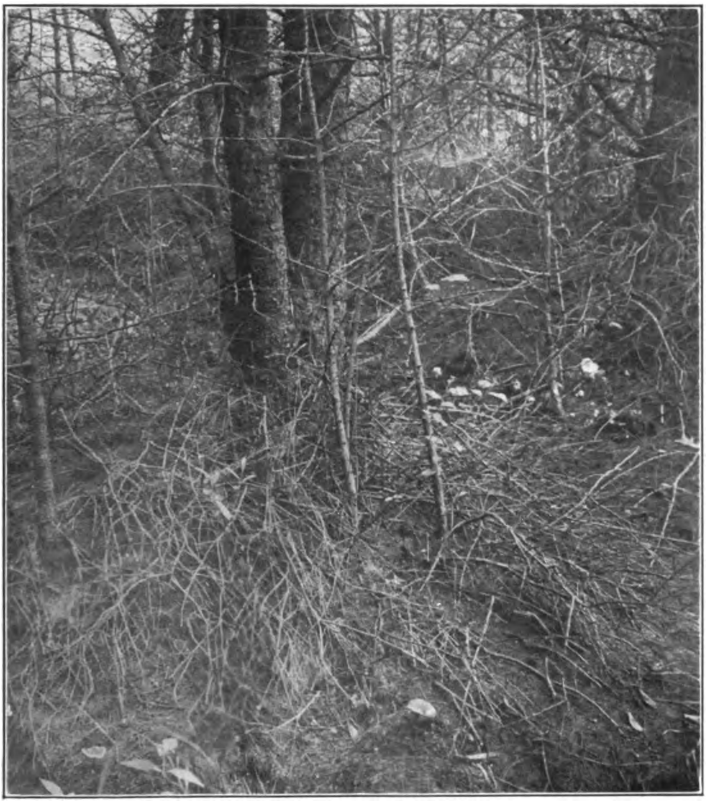

Plate I. Cassandra, dead, under tamarack trees.

Plate II. Taxus canadensis. At times a few rays of sunshine reach into the deepest recesses.

Plate III. Reproduction of maple along the roadway running north and south. The seedlings receive full light during part of the day and are relieved also from competition with the roots of the adjacent forest trees.

far enough from the forest margin to be beyond the influence of side light. He found that all trees absorb between Frauenhofer lines B and C in the red end of the spectrum, then in the region about F in the blue, and beyond H in the violet. Some tree species absorb practically all rays from F to H, while others allow many rays in the indigo region to pass through unabsorbed. Intolerant pine and larch absorb about the same in the red, blue, and violet sections, using practically all the red, but only small amounts of blue and violet. On the other hand the tolerant spruce and beech, besides red, absorb some orange and a large amount of blue, indigo, and violet rays. Ash and oak fall between these two extremes and allow many indigo rays to pass through unabsorbed.

Zederbauer's results, in part at least, are admitted to be inaccurate, because of defects in the apparatus. It will appear later that many other errors must be eliminated before reliable results can be obtained. The fact that leaves of various species of trees absorb different rays of light is interesting, but of itself proves nothing.

Knuchel (10) undertook an exhaustive study of this subject and published a great mass of data which was reviewed by Sponsler (13). His methods were much more refined than those of Zederbauer, and his results are accordingly more trustworthy. His study was devoted especially to the variations in the composition of light which had passed through leaves, through forest crowns and through individual crowns. In the first case he used both sun and shade leaves of basswood, beech, ash, maple, etc. On account of their size no attempt was made to use softwood leaves. Only one illustration of his work with leaves need be given. On July 8, 1911, he took measurements of the composition of diffuse light after it had passed through leaves of the beech and obtained the following results:

TABLE I—COMPOSITION OF LIGHT AFTER PASSING THROUGH BEECH LEAVES (KNUCHEL)

Rays passing	Sun leaves		Shade leaves	
	One leaf percent average	Two leaves percent	One leaf percent average	Two leaves percent
Red	2.5	0	11	2
Yellow	13	0	18.5	3
Green	6	0	16.5	1
Light blue	2	0	5	0
Dark blue	0	0	1	0

Since the sun leaves receive the light first and use the greater part of it, it would seem reasonable to assume that the filtered light is not of much use to the leaves within the crown.

Both hardwoods and softwoods were employed in Knuchel's study of the composition of light in the forests and under single trees. Some of the former consisted of beech, ash, birch and basswood, the latter of spruce, Scotch pine and silver-fir. He set up his spectroscope and made readings in the open. He then moved it into the forest to a previously selected typical or average station and made readings for that forest. Comparisons should enable one to determine the proportion of the total rays absorbed by the crowns. The subjoined table is typical, both for forest and single trees.

TABLE II—COMPOSITION OF LIGHT UNDER CROWNS OF BEECH AND SPRUCE (KNUCHEL)

Beech	Single tree (heavy crown) Single reading percent	Forest Young stand Average reading percent	Old stand Average reading percent
Red	1	3.5	4.5
Yellow	4	6.6	6.4
Green	3	5.4	4.9
Light blue	1	2.6	3.6
Dark blue	1	2.4	3.1

Spruce	Grade A Average reading	Grade B-C Light clearing Average reading	Heavy clearing Average reading
Red	4.2	13.8	33.2
Yellow	5.2	14	33.7
Green	5.5	13.2	34.8
Light blue	4.1	12.5	32.8
Dark blue	4	12.4	32

Knuchel finds that the light under the crowns in hardwood forests has a similar composition to that passing through the leaves of the species composing the forest. The exception found was in the presence of blues in the former case. These blues, he says, come through the openings within the crowns. Under softwoods he found no color especially prominent, the light possessing the same composition as the light in the open; that is to say, no selective absorption was observed.

The present writer doubts whether valuable data can be obtained by the use of the spectroscope in the forest. It seems to him quite clear that the selection of a forest station for spectroscopic work which will represent the average of the forest cover and at the same time be as small as the opening which admits light to the spectroscope, is a difficult if not an impossible task. Furthermore the trustworthiness of the comparisons of these light values with the observations made in the open is questionable, since many changes both qualitative and quantitative in character may occur in light values while the instrument is being moved to a new location and adjusted. Knuchel points out somewhat in detail this possibility of error.

In the solution of the problem of forest succession, little is gained by showing that the weakened light which passes through the sun leaf is comparatively rich in yellow and green rays, unless it is shown experimentally that this light is able to decompose carbon dioxid and otherwise influence the development of the seedlings of the future forest. Our knowledge of the value of the different rays of light in the development of plants is so rudimentary that great care should be used in drawing general conclusions in view of the lack of experimental data.

Further and valuable observations have been made by other workers in this field who have attempted to discover the amount of light actually passing through the leaves unabsorbed, and, finally, to determine the ability of such light to decompose carbon dioxid. For example Linsbauer (11) has determined the amounts of light which pass through sun and shade leaves of the same species and through sun leaves of different species. His results indicate that more light passes through the shade leaves than the sun leaves of the same species, but that the intensities are greatly reduced as shown by the following table, which represents only a small part of his data.

TABLE III—AMOUNT OF LIGHT PASSING UNABSORBED THROUGH LEAVES (LINSBAUER)

	Sun leaf	Shade leaf
Acer platanoides	.0008	.005
Carpinus Betulus	.003	.008 average
Cornus sanguinea	.0004 average	.003
Fagus silvatica	.0046 average	.02
Fraxinus excelsior	.001	.005
Quercus Robur	.006	.003
Rhamnus cathartica	.003	.008
Ulmus montana	.003	.0075 average

He found that the amount of light passing unabsorbed through sun leaves varies with different species from .006 to .0003, totality equalling 1, and that in the case of shade leaves the figures varied from .003 to .02. For a given tree with both sun and shade leaves, the amount of light passing through the leaf unabsorbed decreased from the center of the crown toward the periphery. If the leaves of the tree were formed to use the greatest possible amount of total light available, exactly the opposite result would be expected. Only in the case of Quercus Robur did the sun leaves allow more light to pass through unabsorbed than did the shade leaves.

Griffon (7) studied the action of the light which had passed through leaves. He placed a privet leaf in a chamber with a known percent of carbon dioxid, usually about 9 percent, and placed over the top one or more leaves of the plants undergoing observation. In this way all the light reaching the privet leaf was forced to pass through the experimental leaf. A gas analysis made at the close of the trial enabled him to determine the amount of carbon dioxid which the privet leaf had used. He thus determined the fact that light which passed through one leaf of many species was still strong enough to decompose carbon dioxid, when present in amounts of 5 to 10 percent, but that the rapidity of the process was greatly reduced by this preliminary filtration. In the sycamore maple this was reduced 48 times, but in the beech only seven times. When two leaves were interposed, no decomposition of carbon dioxid whatsoever took place, save that a very feeble action was observed under the two beech leaves. Such data show that although some light passes unabsorbed through both sun and shade leaves and that in some cases it is able to decompose carbon dioxid, yet the amount which passes is so small that it cannot play an important part in the nutrition of the trees or in forest succession. It would seem probable then that a weakened white light rather than a filtered light is the controlling factor in the development of all trees (14).

WEAKENED WHITE LIGHT IN FORESTS

The intensity of the light falling on the forest floor as compared with the total light in the open has been studied by a number of workers. It is sufficient for present purposes to cite only a few of the results thus far obtained.

First among the students of the matter is Wiesner (14) who adapted the work of Bunsen and Roscoe to botanical research. Using photographic paper[1] he attempted to determine the light values in forests in many parts of the world and also the minimum light requirements for many plants. The following table has been compiled by Zon and Graves (16) from the works of Wiesner "for some of our native trees and shrubs and European species commonly grown here."

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[1] Critics of this method often fail to appreciate the fact that photosynthesis is not the only function of the plant affected by light.

TABLE IV—MINIMUM LIGHT REQUIREMENTS FOR SOME NATIVE TREES AND SHRUBS (WIESNER)

Species	Region	Approximate elevation feet	Minimum light intensity
Pinus contorta	Yellowstone Park, Wyo.	6,400	.1666
P. contorta	Yellowstone Park, Wyo.	8,500	.1562-.1449
P. flexilis	Yellowstone Park, Wyo.	6,000	.1250-.1111
Picea parryana	Yellowstone Park, Wyo.	8,000	.0166-.0161
P. parryana	Salt Lake City, Utah	4,000	.0156-.0143
Pseudotsuga taxifolia	Yellowstone Park, Wyo.	5,500-6,000	.0500
Juniperus virginiana	Yellowstone Park, Wyo.	6,000	.2000-.1428
J. communis nana	Yellowstone Park, Wyo.	6,000-8,000	.1111-.1041
Acer glabrum	Yellowstone Park, Wyo.	6,000	.0333
A. saccharium L.	Niagara Falls, N. Y. (600 ft.) and Pocatello Idaho	4,000	.0400-.0250
Populus alba	Utah and Idaho	3,000-4,000	.1250-.1000
P. tremuloides	Yellowstone Park, Wyo.	6,000	.2381-.1666
P. acuminata	Livingston, Mont.	4,500	.1250-.1098
P. deltoides	Colorado Springs, Colo.	6,000	.2500
P. deltoides	Billings, Mont.	3,100	.1111
P. nigra italica	Salt Lake City, Utah	4,250	.0476
P. balsamifera	Colorado Springs, Colo.	6,000	.0625
Betula fontinalis	Mam. Hot Springs, Wyo.	6,000	.0714
Sheperdia argentea	Yellowstone region near Livingston, Mont. ...	4,500	.0714
Vaccinium myrtillus	Yellowstone region ...		.0602

Additional data taken from Wiesner's work appears below.

TABLE V—AVERAGE MINIMUM LIGHT INTENSITY REQUIRED (WIESNER)

Species			Light intensity Average		
Fagus silvatica			0.016		
Acer platanoides			0.018		
A. campestre			0.023		
A. negundo			0.034		
Thuja occidentalis			0.050		
Pinus Laricio			0.099		
Betula verrucosa			0.111		
Populus monilifera			0.166		
Fraxinus excelsior			0.171		
Larix decidua			0.200	0.166	0.250
Picea excelsa	0.050	0.125	0.025	0.016	0.011

These figures represent the averages of many readings. In several cases such large variations in light intensities were found that more than one so-called minimum is given; for example, Acer saccharinum, not given in the table, has values of 0.200 and 0.143. Similar variations are given for Larix decidua. This tree has a so-called minimum of 0.166, 0.250 and 0.200. For Picea excelsa the following values are given: 0.011, 0.016, 0.025, 0.05, and 0.125. In the last case cited the great range in light required from 0.011 to 0.125 would seem to indicate that possibly the method used was not entirely trustworthy.

Clements (3), studying the conditions in mature forests of lodgepole pine, found that the intensity of light in these forests varied from 0.12 to 0.05. He says "the values most frequently found were 0.08 and 0.07 which may well be taken as the normal." His lowest value was 0.016. Germination and growth were fairly good from 0.2 to 0.14, decreasing rapidly below the last named figures. When the light intensities were .08 to .05 there were no vigorous seedlings.

Pearson (12) found western yellow pine seedlings growing in habitats with average light intensities of 0.630 to 0.309. Only in intensities of 0.414 or better were the seedlings marked "good." Especially interesting in the data given for Abies concolor, where there seems to be little connection between the values given and the condition of the growing trees. In an intensity of 0.02 the trees were suppressed, while in light only a little stronger, 0.027 and 0.028, they were marked "good." The trees were doing well in light intensities of 0.048 and 0.068. This lack of uniformity in light requirement for the seedlings in each of these species must be due to some factor other than light, or else the method used is not trustworthy.

The following light values were taken from Pearson's readings, as given by Zon and Graves (16).

TABLE VI—LIGHT VALUES FOR WESTERN TREES (PEARSON)

Condition of seedlings	Pinus ponderosa Average light intensity	Abies concolor Average light intensity	Pseudo tsuga taxifolia Average light intensity
Good	.630	.068	.192
Good	.570	.048	.133
Good	.414	.028	...
Good	...	.027	...
Fair	.385	...	.097
Fair	.309	...	...
Poor	...	...	.049
Poor	...	...	.016
Suppressed	...	.020	...

Hesselman (9) noted great variations in light intensity under the shade of the plant groups which he studied. In some cases these variations amounted to as much as 300 percent. In groups of old spruces the light intensity was reduced to 0.044 and 0.037; in young spruce these values were 0.020 and 0.016.

Ciesler (2) measured light intensities in several types of forests, in each of which he took measurements after three grades of thinning. He found that forests which had been only lightly thinned held back a surprisingly large proportion of the light. The crowns of a severely thinned stand of fir absorbed about 80 percent, a beech stand 80 to 90 percent, and Austrian pine about 60 percent of the total light. In a beech stand which had been lightly thinned the crown absorbed 93 percent and a stand of Austrian pine similarly treated absorbed 80 percent.

The measurements here recorded vary so widely in respect to the so-called minimum that it would seem as if the accuracy of the method must be open to question.

LIGHT READINGS

The light values given in this section of the bulletin were made by the writer or his pupils, with the Clements type of photometer. This is a modification of the Bunsen-Roscoe-Wiesner instruments with which it is possible to make 25 separate readings in the field for each instrument. On account of its size and ease of operation it is adapted admirably to studies in the field. The usual method of operation is described by Clements (4) and need not be repeated here. In our work three persons were used in making the standard, one with a stopwatch, the other two with photometers. Exposures of from one to 25 seconds were made. Whenever possible this standard was made at actual noon on June 21; if clouds intervened at midday, on the first succeeding clear day. In the work done at Camp Bogardus, Douglas Lake, Mich., the standard was made the first clear day after work began. One of the strips of solio paper thus exposed was taken as the standard, glued to cardboard on which was indicated the length of exposure for each of the 25 tints thus obtained, wrapped in black paper and stored in a pasteboard box in the dark room where it was well protected from light and heat and showed little or no change during the season.

In actual work the readings taken in the field are compared with the standard in order to determine the light intensities. The matching of colors was done usually by one and the same person in order as much as possible to eliminate its personal equation. However, repeated tests made with several individuals have shown that appreciable difference in the light intensities as thus determined are uncommon. Hence it is safe to assume the essential accuracy of the observation. The light values determined when the standard was made were given the value "1," and all data were figured to this basis.

It is extremely difficult to get reliable data on the light intensity in the forest because the forest cover is not uniform, the light varies greatly within short periods of time, more particularly because of passing clouds, and there is no satisfactory instrument which will record accurately the light values during an entire day. As has been pointed out, there are many openings in the crowns of the individual trees and between the crowns of the adjacent trees, which cause an uneven shade on the ground. Indeed marked variations occur within a few feet. On this account great care must be taken in making exposures. In the studies now under review while making exposures in woods which were free from shrubs, the operator walked back and forth over a distance of 50 feet. The photometer was so held that the shadow of the body did not fall on the instrument at any time. In other habitats it was impossible to move the photometer through so great a distance, but in no case was it held stationary while an exposure was being made. Nevertheless despite precaution it is impossible to select an average station, for the personal equation is bound to be an all-important factor in its choice.

Absolutely cloudless days are few and far between in Michigan and Vermont. To be convinced of this fact one has only to attempt to make a study of light intensities. He will be struck with the fact that slight clouds pass almost continuously. Light variations which one would not notice ordinarily nevertheless are quite marked, even within the space of a few minutes. On this account, especially in the work of the past three years, simultaneous readings have been made. One person was left in the open control station while others went to the forest stations. If watches are compared and definite times for exposures are agreed upon, simultaneous readings can be made, even at stations which are widely separated. The lack of simultaneous readings is a serious source of error occurring in and vitiating much of the published data on light studies which are now extant. Knuchel (10) recognized this limitation of accuracy in his own work but was unable to rectify it because he did not have access to a sufficient number of instruments to enable him to make simultaneous readings. In the earlier work, before the need of simultaneous readings was felt so keenly, the author made observations at close intervals, usually five minutes apart, in order to avoid as much as possible the error due to changing light intensities in the open.

Even the velocity of the wind has been found to introduce errors in the readings taken in the forest, especially in hardwood forests. The movement of the leaves is an important factor in determining the amount of light passing to the interior of the crown or to the ground cover.

Undoubtedly one of the most serious errors in much of the published data on light intensities is due to the fact that many workers have taken their readings in the middle of the day and on bright clear days. Such readings, of course, are of little value in determining the amount of light available in a given habitat. However, intensities, measured at that time of day may be lower than those to be found in the same habitat earlier or later in the day. Some observations have shown that the maximum may be found before 9 A. M. or after 3 P. M. This is due to the fact that the sun, at different angles, throws varying amounts of light on a given habitat in the forest.

The data reported in this bulletin were gathered:

(1) At First Sister Lake, a small post-glacial pond near Ann Arbor in Washtenaw County, Michigan, latitude about 42° 20′.

(2) In the forests surrounding Douglas Lake, Cheboygan County, Michigan, latitude about 45° 30′.

(3) Near Burlington, Vermont, latitude about 44° 30′.

1. FIRST SISTER LAKE

The vegetation of the bogs of the post-glacial lakes of southern Michigan has been described by several writers. A description of the conditions at this lake has been published somewhat in detail by the writer (1), who pointed out that the vegetation was arranged in zones, three of which were characterized by the dominance of certain trees, namely the Larix, Populus-Acer, and Salix. In some of these zones were found areas in which trees of other zones are prominent, for example Larix-Populus areas; in other places a pure stand of Populus was found which occupied a small area. Except in some parts of the Larix zone, more especially on the side toward the lake, the vegetation is not very dense. Most of the trees are small and the vegetation under them is quite abundant.

For a study of the light conditions in the tree zones, under the shade of the trees, the following stations were established; Control, Larix, Larix-Populus, Populus, Populus-Acer, and Salix. Readings were taken five minutes apart in most instances, beginning each day with the control station which was located near the water's edge. On some days and at some stations, five minutes or less was sufficient in which to make a reading, but in other cases 10 minutes or even more were necessary. Since there are six stations, it required a minimum of somewhat less than 30 minutes in which to take the readings and in many cases more than 60 minutes passed between the reading in the control and that of the Salix station.

The readings were taken at about the same time of day and the areas through which the photometer was moved were as nearly the same each time as could be estimated.

The result of this work is displayed in table VII. The values there given are directly comparable, as they all refer to the common standard, 1. In this instance the standard was made on April 27, a rather early date; but it seemed at that time desirable to make comparisons while the solio-paper used in making the readings was still fresh.

TABLE VII—LIGHT INTENSITIES AT CERTAIN STATIONS IN A PEAT BOG, COMPARED TO A COMMON STANDARD. MOST OF THE TREES WERE SMALL, AVERAGING ABOUT 30 FEET. FIRST SISTER LAKE, ANN ARBOR, MICH.

	April				May				
	5	11	19	27	3	10	17	24	31
Open	.0666	.2000	.6666	.8000	.5333	.5666	.1700	.2166	.5000
Larix	.0250	.0466	.0400	.2500	.1166	.1333	.0440	.0255	.0917
Larix-Populus	.0555	.1250	.7500	.6500	.4666	.4666	.2170	.1700	.3660
Populus	.0555	.1250	.4666	.3000	.2666	.3666	.1361	.1060	.1000
Populus-Acer	.0666	.1580	.6433	.6666	.3666	.5166	.1700	.2111	.2000
Salix	.0611	.1333	.3333	.6000	.3333	.4000	.2110	.1700	.2000

A careful consideration of these figures shows a wide divergence in the light intensities existing in the different zones when these are compared with one another. The only zone with consistently low intensities was the Larix, in which case variations ranged from .125 to .1333. In an adjacent Larix station, in which the cover vegetation was Cassandra in a dying condition, a series of readings gave a maximum light intensity of only .0333. (Plate 1). April 5 was a cloudy day with a light intensity of .0666 at the control station. A comparison of the values at other stations shows that with the exception of the Larix station there was very little variation. The same fact is apparent, but not so striking, in the data secured on May 17. On brighter days greater variations occurred, as may be seen by examining the data for April 27 and May 31. Possibly these wide variations are due to the fact that it is impossible to expose the photometer in exactly the same place when it is moved under the tree crowns. All possible care was taken to avoid error of this kind, but, as has been pointed out already, exactness in this respect cannot be obtained.

In some instances the light intensity "in the shade" was higher than in the open. (April 19, Larix-Populus station; May 17, same station and Salix station). Such occurrences tend to raise a doubt as to the actual value, indeed of the accuracy, of other readings. They are due, of course, to variations in the density of the clouds at the times when different readings were made. These data emphasize the importance of simultaneous readings in any region where clouds occur.

It seemed desirable to determine the percent of light which was cut off by the various trees. The light value in the open each day being regarded as 1 and the readings taken at other stations figured to this basis, the data are presented in table VIII. The effect of the cover here is seen easily. If it is assumed, as is done usually, though without warrant, that the light intensity in the open did not vary while the six readings were being taken, the figures represent the amount of light that was held back by the trees.

For example, if on April 27 the light in the open is 1, then the crowns of Larix cut off 69 percent of the light, Larix-Populus 19 percent, Populus 63 percent, Populus-Acer 17 percent, and Salix 25 percent. A month later, however, on May 31, 82 percent, 27 percent, 82 percent, 60 percent and 60 percent were thus shut out. These consistent increments in shade may be due in part to the fact that the trees were more fully in leaf at the end of May than they were in late April. However, this fact cannot account for the variations found in comparing values obtained May 24 with those of May 31.

TABLE VIII—SHOWING THE AMOUNTS OF LIGHT HELD BACK BY THE TREES

	April 5	11	19	27	3	10	May 17	24	31
	%	%	%	%	%	%	%	%	%
Open	0	0	0	0	0	0	0	0	0
Larix	63	77	40	69	79	77	75	89	82
Larix-Populus ..	16	38	*	19	13	17	*	25	27
Populus	16	38	31	63	50	36	20	52	82
Populus-Acer ..	0	21	4	17	32	9	0	3	60
Salix	9	34	50	25	38	30	*	25	60

*Light stronger than it was in the open.

2. DOUGLAS LAKE

During the summer of 1909 the writer spent some time with advanced students studying the forest conditions in the neighborhood of Douglas Lake, Cheboygan County, Michigan, with a laboratory at Camp Bogardus. The camp was located at the edge of the lake and was in easy reach of several types of forests.

A general survey of the region indicated the existence in a general way of four types; Acer-Fagus-Tsuga, Thuya-Fraxinus-Ulmus, Larix, Populus—Betula papyrifera. Near the camp was a very deep ravine which widened rapidly toward the east. A series of springs yielding a daily flow estimated at 3,000,000 gallons, empties at the head of the ravine. This water flows in a more or less well defined channel into Burt lake. Seven stations in close proximity were located near the head of this ravine. These were designated as Acer, Fagus, Tsuga, Taxus, Mnium, Pinus strobus, and Acer rubrum. As one leaves the hot sandy plain above and descends the steep winding path to the shady ravine, a drop of about 68 feet, physical conditions change rapidly. The relative humidity as determined by an average of eight readings, increase from 53 percent in the control in the sand plain to 83 percent in the ravine bottom; the air temperature at the surface of the soil decreases from 35° C. to 18° C., while on hot days the difference amounts to as much as 30.5° C.; soil temperatures decrease, and light intensities are enormously reduced. The change in midsummer is most delightful.

Of the considerable amount of data recorded, only those dealing with the light intensities will be considered here. The prevailing trees at the first five stations are Acer, Fagus, and Tsuga. At the Mnium and Taxus stations Acer spicatum and Acer pennsylvanicum also occur. Under these, light intensities were extremely low; nevertheless at times the sun was able to send a few beams of direct sunlight into the deepest recesses. (Plate 2).

The reading in the Pinus strobus area showed a much greater light intensity and also much wider variations than at the other stations. The lowest reading taken on a bright day with light intensity in the open at 1 was .0625; on two other days it was .75. The table shows that similar variations in light intensities were found at all stations when the light in the open was 1. At the Mnium station under cover of trees and shrubs, the light was almost four times as strong on July 19 as it was on August 12.

Table IX shows very clearly that marked variations may occur in light intensities at the same station. This is due chiefly to a very discontinuous forest cover.

TABLE IX—LIGHT INTENSITIES NEAR BIG SPRINGS, DOUGLAS LAKE, MICHIGAN

		July			August		
		19	22	29	5	9	12
I	Open............	1.0000	.2500	1.0000	.6666	.5000	1.0000
II	Acer-Fagus-Tsuga	.0083	.0133	.0083	.0083	.0033	.0022
III	Acer-Fagus-Tsuga*	.3333	.0625	.3750	.1250	.1666	.1666
IV	Acer-Fagus-Tsuga		.0166	.0333	.0277	.0222	.0277
V	Taxus canadensis	.0083	.0277	.0416	.0277	.0416	.0555
VI	Mnium sp.	.0083	.0055	.0083	.0083	.0083	.0022
VII	Pinus strobus ..	.0625	.1666	.7500	.1666	.1500	.7500
VIII	Acer rubrum ...	.0125	.0277	.0833	.0416	.0416	.0416

*The high light intensities at station III, located at the bottom of the park leading to the springs, as compared with stations II and IV, are due to a clearing.

In table X an attempt is made to show the effect of the forest cover on bright days as compared with cloudy days. Light in the open varied from .25 to 1. The light values in the open were figured as 1 in every case and the percentage of light at each station computed. These data sometimes are confusing rather than helpful. They conceal important differences in intensity. For example at the Taxus station the forest cover reduces the light intensity on July 22 to .0277, (Table IX), or it holds back 89 percent of the total daylight at that time. On August 12 the light intensity is .0555, and 94.5 percent of the total daylight has been held by the cover. Nevertheless the plants on August 12 have twice as much light for their development as they had on July 22.

TABLE X—REDUCTION IN LIGHT DUE TO VEGETATION EXPRESSED IN PERCENTAGE OF LIGHT IN THE OPEN. DATA GATHERED NEAR BIG SPRINGS, DOUGLAS LAKE, MICHIGAN

		July			August		
	Date	19	22	29	5	9	12
Actual reading in open ..		1.	.25	1.	.6666	.5	1.
Reduction in percentage by shading		Percent	Percent	Percent	Percent	Percent	Percent
I	Open	0	0	0	0	0	0
II	Acer-Fagus-Tsuga ..	99.2	96	99.2	99.8	99.4	99.8
III	Acer-Fagus-Tsuga	66	75	62.5	82.3	66.4	83.4
IV	Acer-Fagus-Tsuga ..		93.4	96.7	95.9	95.6	97.3
V	Taxus canadensis .	99.2	89	95.9	95.9	91.7	94.5
VI	Mnium sp.	99.2	97.8	99.2	99.8	99.6	99.2
VIII	Pinus strobus	93.7	33.3	25	75.1	97	75
IX	Acer rubrum	96.2	89	92.7	93.8	91.7	95.9

Only a few data are available for studying the effect of forest on light intensities as they vary from hour to hour with the changing of the sun. Two cases are cited by way of example, but since in these trials it was not possible to take simultaneous readings, an unavoidable source of error was introduced. Four readings taken an hour apart under an Acer-Fagus-Tsuga cover show that the crowns cut off 60, 93, and 81 percents of light respectively. These figures represent a variation in light intensities of from .0166 to .3000. At the time of the latter intensities, the numerous seedlings of Acer and Tsuga had a sufficient light for all purposes. In an adjacent stand of Tsuga, the morning readings were 94 and 95 percents, which show a fairly uniform cover for that period. (Plate IV).

Numerous seedlings of Fagus and Acer were found in habitats the light intensities of which were .0250 and even lower. That higher light intensities with proper moisture conditions are favorable for their development, can be seen by a comparison of the reproduction in deserted road-beds with that of adjacent areas. These wood-roads receive the full sunlight for a few hours at least on each bright day. Acer seedlings which cover the roadway are as thick as if grown in a seed-bed, whereas very few are found in the woods three rods away where the light was much weaker and root competition with the old stand of trees was more intense. (Plate III).

The data presented emphasize the fact that in the natural woods variations may occur in the amount of light available for seedlings, that in other words the intensity of the forest shade is an extremely variable factor. (Plate V).

3. BURLINGTON

In order to determine the relation of crown cover to the surface of the forest, a series of studies was started in definite areas. These areas were 100x100 feet and were subdivided into 100 squares, each 10x10 feet, the boundaries being marked with common wrapping cord. Then a map of the area was made, locating the size and kind of each individual tree, after which the crown was projected upon the ground and mapped. In some instances shrubs and herbaceous forms also were shown.

These maps and the data previously given show that there is considerable variation in the amount of light reaching the surface under a forest. The attempt was made now to determine the total light that would fall on a group of seedlings during the day, but in view of the lack of satisfactory self-recording instruments this was found to be a very difficult problem. The most satisfactory way seemed to be to determine as accurately as possible by the use of a camera how much light fell on a given point, a method which has been suggested by Frederick (6), but has not been used to any great extent. With the camera located at one and the same point, eight 5x7 plate exposures were made in the college woods on August 3, 1912, beginning at 2 P. M. The camera was pointed successively due east, southeast, south, southwest, west, upward with an eastern angle, directly upward and, finally, upward with a western angle. The first five exposures were meant in a way to follow the course of the sun across the sky. Velox prints were made and the light patches removed, as nearly as this was possible. In some instances it was necessary to estimate the amount to be cut out because of the fine branches and leaves.

The data are given in table XI.

TABLE XI—LIGHT DATA TAKEN IN THE COLLEGE WOODS BY USE OF CAMERA

	Original weight of paper grams	Final weight of paper grams	Shade percentage	Light percentage
East	2.970	2.690	90	10
Southeast	3.046	2.400	78	22
South	3.021	2.221	73	27
Southwest	3.062	2.370	77	23
West	3.038	2.801	92	8
Upwards eastern angle	2.885	2.395	83	17
Upwards	3.136	2.160	68	32
Upwards western angle	3.067	2.580	84	16

These figures show that during the day a considerable amount of light penetrates to the ground cover, despite the fact that the forest cover eliminates a large percentage. They also show how useless it is to attempt in such a place as a forest to determine available light for seedlings by means of isolated readings.

The photometer readings for the station near this location for the summer gave an average light value of only .0554 above some small white pines and .0374 below these pines. Table XII displays the average of a large number of readings taken in the natural forests of Pinus strobus or Tsuga near Burlington, together with reproduction statements.

TABLE XII—AVERAGE OF READINGS NEAR BURLINGTON

Location	Light intensity	Seedlings
Williston		
Pasture	.6766	none
Forest	.0266	none
Burlington, forest chiefly Pinus strobus		
Level ground	.0154	many
Level ground, above 3-foot seedlings	.0554	
Level ground, under 3-foot seedlings	.0374	some
South slope	.0278	none
North slope, above herbaceous plants	.0364	
North slope, under herbaceous plants	.0069	many
West slope	.0246	none
East slope	.0088	none

The data in table XII show no marked relationship between light intensities and the presence of seedlings. At one station the average reading was only .0069, yet the ground was well covered with seedlings whereas none grew at a nearby station where the light intensity was .0088 or a quarter greater. Seedlings were growing in this woods at stations where light intensities were .0374, .0069 and .0154; but none grew at adjacent points where light intensities were .0278, .0246 and .0088.

A study of the foregoing tables soon convinces one that the present methods of determining light values in the forest are unsatisfactory. Too little attention has been paid to the fact that the so-called shade is a discontinuous shade and a constantly changing factor. The variations in light intensity due to clouds, the impossibility of making equal exposures in repeated readings, the variability of the forest cover thus requiring the operator to choose a "typical station for the forest under consideration," and the habit of reading only on bright days about noon; all these make for inaccuracy and emphasize the difficulty, if not impossibility, of determining the relation of forest trees to light by a "study in the forests."

The results of the work in the forests showed the necessity of devising a habitat wherein continuous shade may occur. Accordingly a series of frames was made of 1x1 inch lumber, each frame being two inches larger than the one preceding it in the stack. The smallest frame was 18 inches square. The larger frames were somewhat bulky, but by using iron braces at the angles a sufficient rigidity was preserved. Seven of these frames were covered with white cheesecloth, 36 threads to the inch, and several with similar cloth which had been dyed black.

A ditch large enough to admit the arm of the operator was dug under the north side of the frame or frames. When his arm was in place with the photometer under the covers, a black cloth was packed around it completely filling the space between the arm and the ditch to keep out all light from entering around the arm. While a reading was being made under the shades, a second operator made a simultaneous reading in the open. When several covers were used a long time exposure was found necessary, and two or more readings were made in the open to compare with the reading under the covers, thus taking cognizance of possible changes in total light which might occur during the interior exposure. Readings were taken on both clear and cloudy days. Table XIII may be taken as a sample. It displays a series of readings taken between 12 and 12:35 on August 16, 1912, when the sky was cloudless and the light in the open was 1.

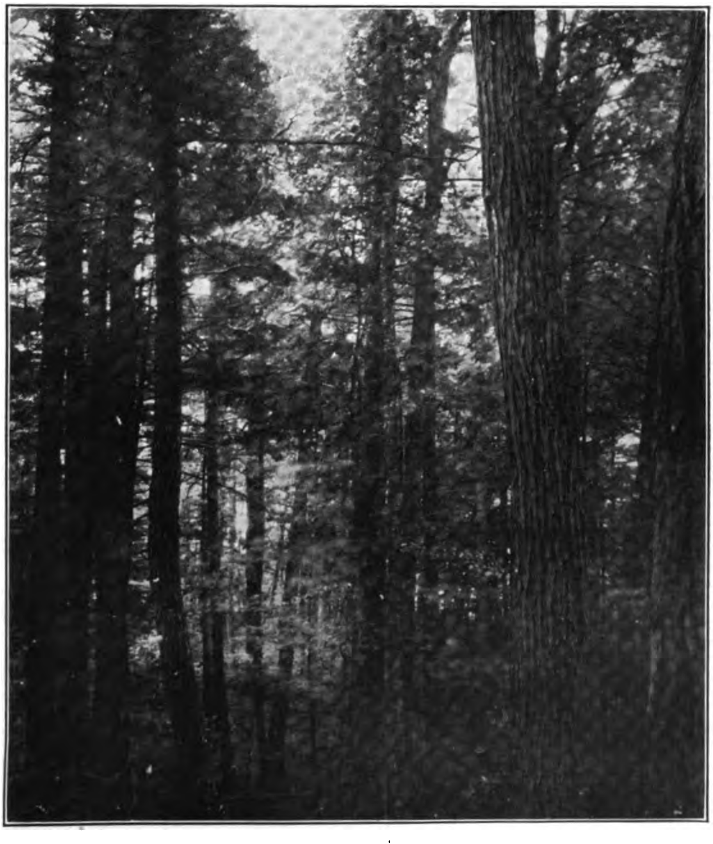

Plate IV. Discontinuous shade in a dense stand of hemlock near Douglas Lake, Michigan.

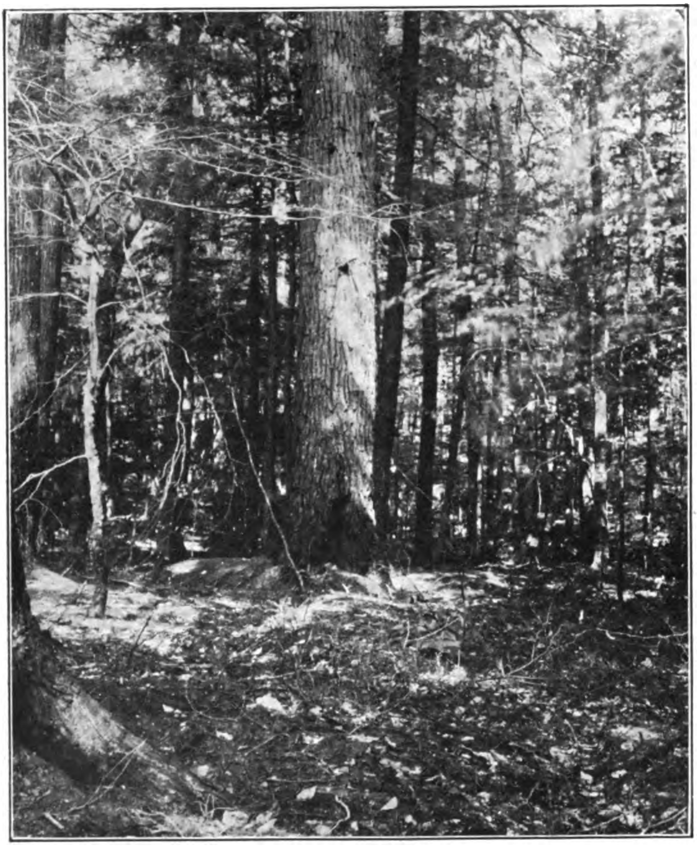

Plate V.—View in maple, beech, hemlock stand near Douglas Lake, Michigan.

TABLE XIII—LIGHT INTENSITIES IN CONTINUOUS SHADE PRODUCED BY CHEESE-CLOTH COVERS ON A CLEAR DAY

Light Intensities In the open	Number of white covers	In the shade
1	1	.4000
1	2	.2220
1	3	.1666
1	4	.1250
1	5	.0833
1	6	.0625
1	7	.0500

Similar data to that in the last table are displayed in table XIV, except that the readings were taken on a cloudy day between 12:04 and 12:26 M. August 14, 1912.

TABLE XIV—LIGHT INTENSITIES IN CONTINUOUS SHADE PRODUCED BY CHEESECLOTH COVERS ON A CLOUDY DAY

Light Intensities In the open	Number of white covers	In the shade
.4999	1	.2222
.4333	2	.1333
.5666	3	.0833
.5666	4	.0555
.4333	5	.0417
.4999	6	.0333

A continuous shade of any desired percent of total light, within certain limits, can be maintained during the entire experimental period. In this shade a series of trials was conducted to determine the minimum light intensity at which white pine, balsam fir, and hemlock seedlings could produce starch, the plants being grown under the screens. It was found that when the light intensity was so far reduced as to register .0266, no starch whatever could be detected in the leaves in the white pine. The hemlock seemed to reach its minimum at about .005. No starch could be found in plants from under two black and four white screens, whereas traces of starch were found in these plants under one black and seven white screens with the same light intensity. These trials are being continued using several more varieties.

It is becoming increasingly evident that the relation of forest tree growth to the light environment can be solved only by carefully planned and executed experiments in the greenhouse and nursery where it is possible, to some extent at least, to control the factors influencing plant growth. We cannot hope that much new information will be obtained concerning this intricate subject by "a study of light in the forest."

The writer has under observation one-year-old seedling trees of white pine which grew in the summers of 1914 and 1915 under large cheesecloth shades which reduces the light approximately to the values shown in tables XIII and XIV. One set was transplanted to give each tree space for the development of its root system; the other set was left as they came up after broadcast sowing.

A comparison of the size, color and general vigor of the two sets seems to indicate beyond a doubt that the chief factor of the slow development of the latter set is not lack of light but some other factor, possibly root competition for water and food in the soil.[1]

CONCLUSIONS

1. The word "tolerance" should be stricken from the vocabulary of forestry students unless to it can be accorded a more comprehensive definition. It is taken generally to express a light relationship, but really it expresses not a light relationship, but the total relationship of a tree to all factors of the habitat.

2. The filtered light in the forest has little value as a means of decomposition of carbon dioxid; the important light in the forest is weakened white light.

3. Light intensity data thus far published in forest light studies as a rule are averages of many readings, usually taken without reference to check readings in the open. They have been taken commonly on clear days about noontime and consequently readings usually are too high. Furthermore, the fact that shade in the forest is discontinuous is additional evidence of the untrustworthiness of much of the published data.

4. The relation of tree growth to light as an influencing factor can be determined only by controlled greenhouses and nursery trials. Light readings in the forest are of little value.

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[1] The writer is well aware of the fact that these cheesecloth shades have a decided influence upon all factors of this artificial habitat. Continuous records of changes in humidity, air and soil temperatures were taken during the season. Rainfall, soil moisture, and evaporation data were also collected. These figures will be published after further experimental data are available.

LITERATURE

1. Burns, G. P. Botanical Survey of the Huron River Valley, 8. Edaphic Conditions in Peat Bogs of Southern Michigan. Bot. Gazette, 52 (August, 1911).
2. Cieslar, Adolph. Einiges ueber die Rolle des Lichtes im Walde. Mitteil. a. d. Forst. Versuchswesen, Oesterreichs (1914).
3. Clements, F. E. The Life History of Lodgepole Burn Forests, U. S. Dept. Agr., For. Serv. Bul. 79 (1905).
4. Clements, F. E. Research Methods in Ecology, Lincoln, Neb. (1905).
5. Fricke, Karl. "Licht und Schattenholzarten" ein wissenschaftlich nicht begruendetes Dogma, Centralbl. f. d. ges. Forstwesen, 30 (1904).
6. Friedrick, J. Die Photographie im Dienste des Versuchswesens, Centralbl. f. d. ges. Forstwesen (1895).
7. Griffon, ——. L'Assimilation Chlorophyllienne dans la lumiere solaire qui a traverse des feuilles, Rev. g. d. Botanique, 12 (1900).
8. Hartig, R. Anatomie und Physiologie der Pflanzen, p. 177 (1891).
9. Hesselman, Henrik. Zur Kentniss des Pflanzenlebens schwedischer Laubwiesen, Beih. z. Bot. Centralbl. 17 (1904).
10. Knuchel, Hermann. Spektrophotometrische Untersuchungen im Walde. Mitteil. d. Schweizerischen Centralanstalt f. d. forst. Versuchswesen, 11 (1914).
11. Linsbauer, L. Untersuchungen ueber die Durchleuchtung von Laubblaettern, Beih. Bot. Centralbl. 10 (1901).
12. Pearson, G. A. See Zon and Graves (16).
13. Sponsler, O. L. Proceedings Society American Foresters, 10 (1915).
14. Wiesner, Julius. Der Lichtgenuss der Pflanzen, Leipsig (1907).
15. Zederbauer, Emerich. Das Lichtbeduerfniss der Waldbaeume und die Lichtmess Methoden, Centralbl. f. d. ges. Forstwesen, 33 (1907).
16. Zon, R. and Graves, H. S. Light in Relation to Tree Growth, U. S. Dept. Agr., For. Serv. Bul. 92 (1911).

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BURLINGTON, VERMONT

THE TREES OF VERMONT

by G. P. BURNS and C. H. OTIS

1791

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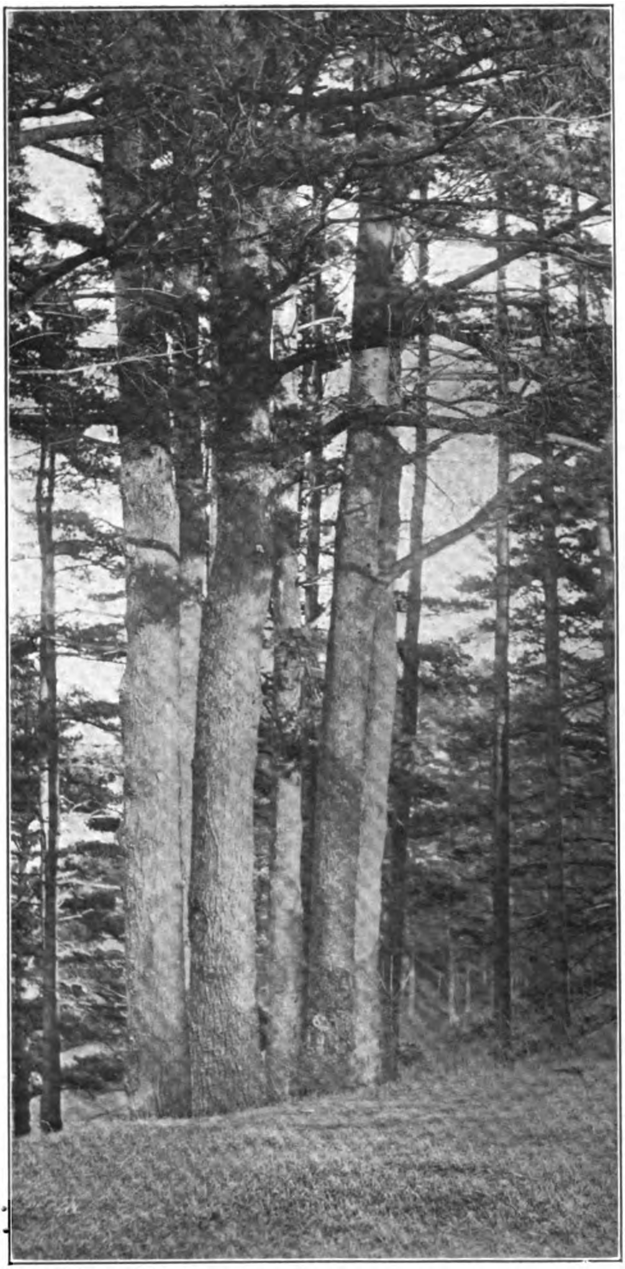

Photo by H. F. Perkins.

A NATURAL GROUP OF WHITE PINE ON THE GROUNDS OF THE UNIVERSITY OF VERMONT.

BULLETIN 194: THE TREES OF VERMONT

By G. P. Burns and C. H. Otis[1]

INTRODUCTION

The supply of bulletin 73, entitled "The Trees of Vermont," has been exhausted for several years. Repeated calls from all parts of the State and especially from the schools make it evident that its revision and reissue would be welcomed.

The present publication represents a revision of Bulletin 73 of the Vermont Agricultural Experiment Station, issued in 1899, and of Bulletin 16, Vol. XIV, N. S., of the University of Michigan, issued in 1913 under the authorship of the junior writer[2]. In the preparation of the present bulletin the authors have followed largely the general scheme and arrangement of the Michigan publication. Two chapters, "How to Study the Trees" and "Artificial Keys, How Made and Used," except for a few minor changes, are from the Michigan bulletin. The artificial keys for identification and the manual of trees have been adapted to the slightly different Vermont conditions. Most of the reproductions published in this bulletin have been made from new plates photographed from the drawings originally used to illustrate the Michigan bulletin. Credit has been indicated in each case. Finally, there have been added a series of bark photographs by the senior author, while the junior has contributed four original plates of drawings and accompanying descriptions and a section dealing with the identification and structure of Vermont woods. Upon the senior author has devolved the final bringing together of the component parts and the necessary editorial work involved.

This bulletin is intended primarily for the use of pupils in our public schools and of persons not especially trained in botany. For this reason the use of technical terms has been avoided whenever possible. In several cases such terms were necessary, but with the help of the glossary (page 233) their meaning can be easily understood.

The order of arrangement and nomenclature are essentially those of Gray's Manual. Following a tendency which is steadily gaining favor, all species names are printed with a small letter, regardless of their origin.

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[1] Professor Otis, formerly curator of the botanical garden and arboretum of the University of Michigan, spent several months during the past year at this institution, collaborating with the senior author in the preparation of this bulletin.

[2] The authors take this occasion to express their appreciation of the courtesy of the University of Michigan authorities in allowing them to make such liberal use of the material from the former bulletin in their present work.

Two sets of keys are given. One is based upon characters which are present during the summer; the other uses the winter characters as a basis for identification.

Photographs have not been used as illustrations because they are too indefinite and give all characters equal emphasis. This generally conceals the essential marks necessary for identification and affords little help to the student. Accurate line drawings are substituted for photographs, since they have proved to be much more serviceable in classwork.

It is believed that with the aid of the drawings and descriptions given in this bulletin any person will be able to identify any Vermont tree. If, however, difficulty is found in naming a given tree, specimens of flowers, fruit, leaves, wood, etc., mailed to the Extension Service, Burlington, Vermont, will be named without charge, if of such a character and received in such condition as will admit of identification.

HOW TO STUDY THE TREES

Trees are such familiar objects that the people who dwell in nearly every portion of this country see them daily. Trees give cooling shade in our parks and dooryards and along our highways; they lend their beauty to the landscape and relieve it of monotony; they yield many kinds of fruits, some of which furnish man and the animals of the forest with food; and they furnish vast quantities of lumber for a multitude of uses. It is important then that every person, whether in the schools or beyond school age, should become acquainted with our trees. Most people know a few of the more common trees but are ignorant of the great wealth of trees of various kinds about them. Some persons who may have wished to learn more have been hindered for lack of a teacher and others have been dismayed by the very multitude of manuals to which they have had access.

In beginning a study of trees the student should be careful to confine himself to well established facts. Once started he should proceed slowly, assimilating each new discovery before seeking another. He should begin with the trees nearest home and then becoming familiar with these in all their aspects, he should extend his trips afield. Not only should he be able to name the trees when they are fully clothed in summer garb, but he should know as readily the same trees when only the bare branches stand silhouetted against the sky if he desires to gain a thorough knowledge of his subject.

The characters which are used in studying the trees are habits, leaves, flowers, fruits, buds, bark, distribution and habitat. These will be discussed briefly in the next few pages, the same order that is used in the detailed descriptions of species being maintained in the present discussion. A few drawings also will be added to make certain points clear and to show comparative forms.

NAME.—Every tree has one or several common names and a scientific or Latin name. Some of these common names are merely local, while others have a more extended use. A few names apply to totally different species. Thus, cottonwood in Vermont is *Populus deltoides,* in Idaho and Colorado *Populus angustifolia,* in California *Populus fremontii* and in Kentucky *Tilia heterophylla.* While it should not be forgotten that in common speech it is proper as well as convenient to call trees by their common names, yet, in view of the many uncertainties pertaining to their use, a scientific name at times is absolutely essential to the clear understanding of what is meant. Latin is the language in universal use by all scientists. No longer used by any civilized nation, it has become a dead language and consequently never changes. Its vocabulary and its constructions a thousand years hence will probably be the same that they are today. Being in universal use among scientists of all nationalities no confusion arises from the use of a Latin word. The oak in Germany is known as *Eiche,* in France as *chêne* and in Spain as *roble,* but the Latin word *Quercus* is the same in all these countries.

A scientific name as applied to trees consists at least of two parts, as *Quercus alba.* The first is the genus name and always is written with a capital letter, the second is the species name and is written with a small letter, the two names constituting the briefest possible description of the particular tree. It is customary to add to these the name or an abbreviation of the name of the person who first gave the name to the tree, as *Quercus alba* L., the abbreviation standing for Linnaeus. Sometimes a third name is used, as *Acer saccharum nigrum,* referring in this instance to a variety of the ordinary Sugar Maple. In some cases trees have more than one Latin name. When this is true the synonym or synonyms are placed in brackets after the accepted name.

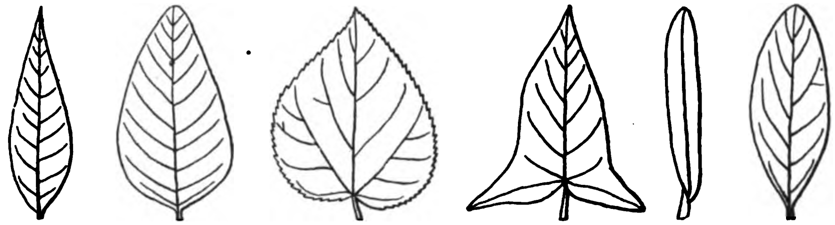
Genera which bear a relationship to each other are placed in the same family, the family name always having the characteristic ending—*aceae.* Related families again are grouped into orders, with the characteristic ending—*ales.* Orders in like manner are arranged into larger groups, called classes, and the latter into still larger groups, divisions, etc., each with its characteristic ending. Thus, *Acer saccharum nigrum* (Michx. f.) Britt. is classified as follows:

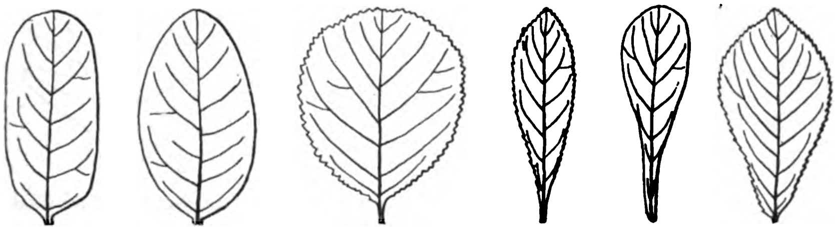
Division—Spermatophyta
  Subdivision—Angiospermae
    Class—Dicotyledoneae
      Order—Sapindales
        Family—Aceraceae
          Genus—Acer
            Species—saccharum
              Variety—nigrum.

HABIT.—Habit, or the general appearance of a plant, is an important character of identification, especially as we become more and more familiar with the trees. Two main types are recognized, based on the manner of the branching of the trunk, the upright and the spreading. In the one the trunk extends straight upwards without dividing, as is typical in most of the conifers; in the other the trunk divides to form several large branches and the broad, spreading crown of most of our broad-leaf trees. In either case the crown may be regular in outline or very irregular, straggling or straight-limbed. Moreover, the tree growing in the open, where there is no crowding and plenty of light, may differ greatly from the tree in the forest, where the struggle for existence becomes very keen. A short, thick trunk and a low, spreading, many-branched crown characterize the tree in the open, whereas the forest tree has a long, slender, clean trunk and a narrow crown of few branches. In the descriptions of trees in this bulletin, unless otherwise stated, the habit in the open is the one given. Again, the tree may have been injured by storm or insect at some period of its growth and its natural symmetry destroyed. Moreover, the age of a tree has a great influence on its outline, young trees generally being narrow and more or less conical, broadening out as they become older. We may say, then, that each tree has an individuality of its own, little eccentricities similar to those that make people different from one another. And just as we have little difficulty in recognizing our friends at a distance by some peculiarity of walk or action, so we are able to recognize many trees at a distance by some peculiarity of form or habit.

LEAVES.—With the advent of spring the buds of our broad-leaf trees swell and burst and the leaves come forth and clothe the trees with mantles of green, hiding the branches which have been bare through the cold winter months. The evergreens, too, take on fresh color and commence a new period of growth. The beginner in botanical study finds the leaves the most interesting portion of a tree and one which affords him a ready means of identification. It must be remembered, however, that leaves vary greatly in size, shape and general appearance. For example, the leaves on a flourishing sprout are usually relatively large, whereas they may be much smaller on a stunted tree of the same species growing nearby and subjected to adverse circumstances.

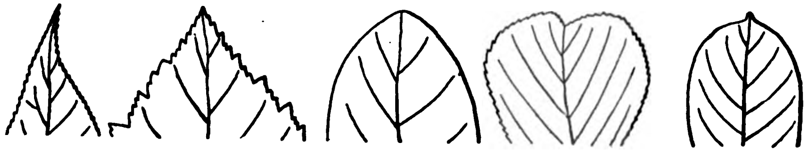
I. LEAF OUTLINES





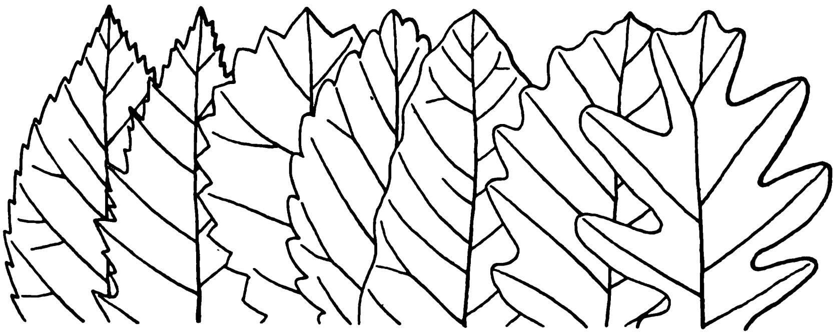
The leaves of a big white oak standing in the yard may be hardly lobed on the lowermost branches, while higher up they are deeply cut. However, in spite of the many modifications they undergo, the leaves of any one species have certain rather constant characteristics which are found in all forms, and the student who has once learned what these are will have little difficulty in selecting and recognizing typical specimens.

II. LEAF TIPS



Leaves are either persistent, as in most of our conifers, which remain green all winter, or they assume various colors with the coming of the frost, and drop to the ground early in autumn although often they hang dead and lifeless far into the winter. The characteristics of leaves which we are accustomed to consider in determining their relationships are their position or arrangement on the branch, whether simple or compound, size, shape, texture, color, the amount and character of pubescence, the character of the margin, venation, etc. The following diagrams will serve to illustrate some of the ordinary forms and shapes of leaves, their margins, etc.

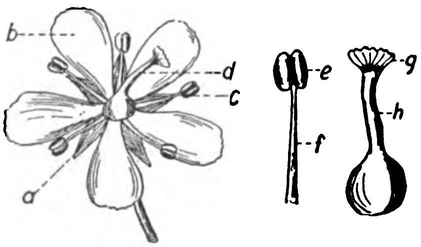
III. LEAF MARGINS



Serrate. Doubly Serrate. Dentate. Crenate. Undulate. Sinuate. Lobed.

FLOWERS.—Every tree when old enough bears flowers in its proper season. Some of these, as the hawthorns, locusts and horse-chestnuts, are very showy; others, like the oaks and hickories, are comparatively inconspicuous. Some are brilliantly colored, while others are of the same color as the leaves. Nevertheless, the flowers are very accurate means of classification, and the only drawback to their use for this purpose is the fact that they last for such a little while each year.

IV. PARTS OF A FLOWER



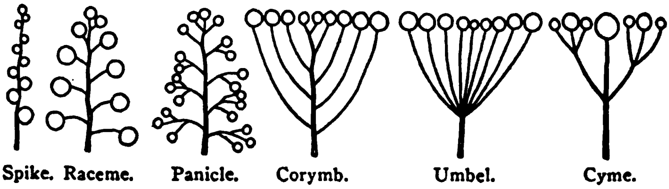
Perfect Flower. Stamen. Pistil.

a. Sepal (Calyx).
b. Petal (Corolla).
c. Stamen.
d. Pistil.
e. Anther.

f. Filament.
g. Stigma.
h. Style.
i. Ovary.

Just as there are male and female in the animal world, so the male and the female are found in the plant world. A few of our trees, as the locust, basswood and cherry, have perfect flowers, bearing both stamens and pistil. The great majority, however, have unisexual flowers, bearing either stamens or pistils, but not both. When both male and female flowers are found on the same tree, the flowers are said to be monoecious, and when male flowers occur on one tree and the female on a different tree, the flowers are said to be dioecious. The cottonwood of New England is dioecious and each little seed is surrounded by a tuft of long, white hairs which enables the wind to carry it considerable distances from the parent tree, to the disgust of people living within its range. The planting of the cottonwood is forbidden within the bounds of several cities on account of this objection. Since it is desirable in some places to plant this rapidly growing tree, as in cities burning large amounts of soft coal, it is a distinct advantage to know that the male trees may be planted safely, since they bear no seed and shed no "cotton."

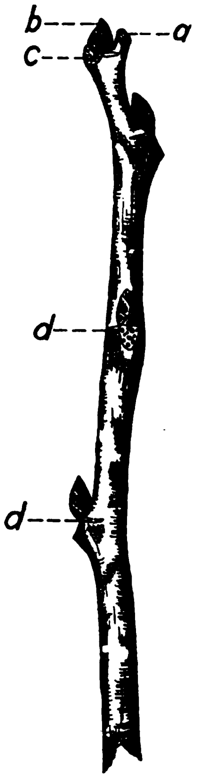
V. TYPES OF INFLORESCENCES



Before trees can produce fruit their flowers must be fertilized, i. e., pollen from the anther of a stamen must come in contact with the stigma of a pistil. Some flowers are self-fertilized and others are cross-fertilized. For a long time it was not understood how fertilization was accomplished, but now we know that many insects, like the nectar-loving bees and butterflies, and in other instances the wind, transport the pollen from one flower to another, often miles being traversed before the right kind of flower or a flower in the right stage of development is found. And many are the modifications of flowers to insure this transference of pollen.

FRUIT.—So numerous and so varied are the forms of tree fruits that it would be only confusing to state their characters. Some fruits, such as the achenes of the poplars and willows, are so small and light that they are carried long distances by the wind; others, like the hickory nuts and walnuts, are too heavy to be wind-blown. Many fruits are of considerable economic and commercial importance and are gathered and marketed on a large scale. Among these are the hickory nuts, walnuts, chestnuts, etc. Some, not esteemed by man, form an important article of diet for the birds and small animals of the forest. Unfortunately there are a number of limitations to the usefulness of fruit for identification purposes. Some trees require years to mature their fruit. Many trees, while producing an abundance of fruit at certain intervals, bear none at all or only very small and uncertain quantities between the years of abundance. Again, in the case of dioecious trees, only the female or pistillate bear fruit. Notwithstanding these limitations tree fruits are a very valuable aid to the student, and he should always search closely for evidences of their presence and character.

VI. WINTER TWIG OF RED MULBERRY

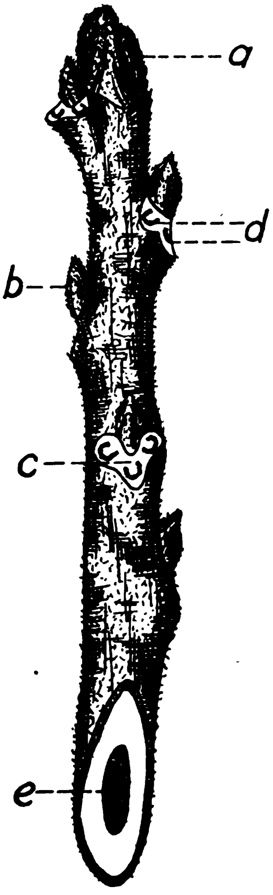


a. Tip-scar.
b. Lateral bud.
c. Leaf-scar.
d. Stipule-scars.

WINTER-BUDS.—Buds, with their accompanying leaf- and stipule-scars, form the basis of tree identification in winter. The size, color, position with reference to the twig, number and arrangement and character of bud-scales, etc., all are characters of the greatest value in winter determinations. Buds either are terminal or lateral, depending on their position on the twig. A lateral bud is one situated on the side of a twig in the axil of a leaf-scar. A terminal bud is one situated at the end of a twig, where it is ready to continue the growth of the twig the following spring. To the presence or absence of the terminal bud is accorded much importance in the keys on pages 162 and 163, which enable one more surely to identify a tree. Inasmuch as the determination of this point gives the beginner some trouble at first, it is hoped that the accompanying diagrams and explanatory remarks will serve to make the distinction clear.

In the elms, willows, basswood and many other species the terminal bud and a small portion of the tip of the twig dies and drops off in late autumn, leaving a small scar at the end of the twig (a, fig. VI). The presence of this tip-scar indicates that the terminal bud is absent. Often a lateral bud will be found very close to the tip-scar (b, fig. VI), which, bending into line with the twig, makes it appear to be a terminal rather than a lateral bud. However, the presence of a leaf-scar immediately below it shows it to be a lateral bud (c, fig. VI). The unaided eye can discern the tip-scars on some of the larger twigs, but a hand lens will be found necessary when the smaller twigs are under observation.

VII. WINTER TWIG OF BLACK WALNUT



a. Lateral bud.
b. Lateral bud.
c. Leaf-scar.
d. Bundle-scars.
e. Pith.

The arrangement, size and shape of the leaf-scars (c, fig. VII) are important factors in identification by winter characters. Within the leaf-scars are one or more dots (d, fig. VII), sometimes quite inconspicuous, often very prominent. These are the scars left by the fibro-vascular bundles which run through the petiole into the blade of the leaf, and are designated as bundle-scars. There may be many as in the oaks, three as in the poplars and cherries, or only one as in tamarack and the spruces; and they may be arranged in a U- or V-shaped line, or they may be without definite order. Often stipule-scars (d, fig. VI) occur on either side of the leaf-scar and are caused by the fall of a pair of small leaflets called stipules, located at the base of the leaves. Their form varies according to the form of the stipules which made them

BARK.—The woodsman uses the bark more than any other feature in identifying trees, and often he is able in this manner to distinguish trees with much accuracy at great distances. However, the appearance of bark differs so greatly with the age of the tree and with its environment that it is difficult to describe it accurately. Some characters are distinctive, however, and serve as a ready means of identification; as for example the peeling of the sycamore and paper birch, the "shelling" of the shellbark hickory and the mucilaginous inner bark of the slippery elm.

WOOD.—Under this heading are exhibited some of the general characteristics of wood. While it is not expected that this information will be of any particular value to the student of tree botany in identifying living trees, it happens often that such a one finds himself in the midst of felling operations or in the lumberyards; and under such circumstances a knowledge of the wood characters may be of considerable value. Few, if any, manuals or bulletins have been published dealing in a simple but comprehensive manner with the structure of wood. Especially is this true of the photographs or drawings accompanying such works. It hardly comes within the scope of this bulletin to discuss in detail all the woods of all the tree species growing in Vermont, although such a study doubtless would be worth while. Yet there does seem to be an urgent demand for such a publication dealing with our more common trees; and hence a detailed study has been made of such of our woods as are of importance from a lumbering standpoint. Illustrations, showing cross-, radial- and tangential-sections, accompanied by descriptions and keys, have been brought together in a chapter at the end of the manual proper, to which are referred persons desirous of a more thorough acquaintance with our commercial woods.

DISTRIBUTION AND HABITAT.—To a lesser extent do distribution and habitat of a species aid in the identification of a tree. It is a distinct advantage to know that the wild plum is native in western Vermont only and that the black gum is limited to the southernmost portions of the state. So, too, knowing the water-loving habit of the swamp spruce, we would not expect to find it flourishing on a rocky mountain-top.

The characteristics, then, which are used to identify the trees about us are many. Not all will be available at any one time, and not all have been mentioned in the foregoing pages nor in the manual. It is our opinion, however, that the student will not be handicapped greatly by this lack of detail, but rather that he will take great interest and genuine pleasure in discovering these things for himself.

ARTIFICIAL KEYS, HOW MADE AND USED

An artificial key is a scheme for identifying any unknown object under consideration easily and quickly. This bulletin being devoted to the trees of Vermont, its keys are intended to make it possible for any person, even if his botanical training be meager, to determine what native trees grow about his home or farm or in any Vermont city park or woodlot. With certain modifications and within limitations they may prove useful in other localities as well.

Since many people are unfamiliar with the construction and use of keys for purposes of identification, it is the purpose of the following paragraphs briefly to outline the principles upon which they are built and the manner in which they are used.

The keys are based on the most striking similarities and differences manifested by the various parts of trees—twigs, buds, leaves, etc.—that is to say, those characters which stand out in bold relief, which catch the eye at first sight. Two alternatives are presented, either a character *is* or *is not* presented; these are the only choices possible. Indeed, further divisions are unnecessary and lead only to confusion and possible oversight. The two diametrically opposed characters are said to be coordinate in rank. In the keys they are preceded by the same letter or letters (*a* and *aa* or *b* and *bb,* etc.) and are set at the same distance from the left margin of the page. Often *a* and *aa,* or *b* and *bb* are divisible further into other groups; in every case the characters are opposed (a positive and a negative) and are given coordinate rank. It is desirable for mechanical reasons to divide the main divisions of the key more or less evenly, but this is not always feasible, nor should it be adhered to strictly.

The nature and use of a key may be made the more clear by a homely but concrete example. Let us suppose that it is desired to construct a key in order to distinguish from one another five houses in a city block. Three of these houses are built of wood, two of brick, and of the three wooden houses two are painted white and one brown. We may classify them as follows:

a. Houses wood.
  b. Body paint brown .... *Smith's house*
  bb. Body paint white.
    c. Trimmings green color .... *Jones' house*
    cc. Trimmings slate color .... *Brown's house*
aa. Houses brick.
  b. Roof gray slate .... *Johnson's house*
  bb. Roof red tile .... *Public library*

It is desirable in many instances to add other characters to lessen the likelihood of confusion, in cases where the characters chosen are not distinct, and in order to show the user that he is on the right track. Thus, in the example just given, green color and slate color might be confused owing to certain defects of the eye, to a coating of dust or deficiencies of the light. Hence we would be justified in adding to the above statements additional distinguishing characteristics. Thus:

bb.
  c. Trimmings green color; gable roof.............*Jones' house*
  cc. Trimmings slate color; mansard roof.........*Brown's house*

The keys in this bulletin are constructed on these principles. They are not always as simple as the illustration just used, but if the reader has mastered the house illustration he will have little or no trouble with the larger keys. In order that the usage of the keys may be made the more clear, the following example, couched in language using the personal pronoun, is set forth at some length. The reader is advised to trace it from beginning to end as a ready means of familiarizing himself with the use of and possibilities of the key system.

Suppose that during a summer stroll you come across a large tree with rough, flaky bark and thin, lobed leaves which you do not know. Turning to the *Summer Key to the Genera* on pages 16 to 19, you find first *a Leaves simple,* and contrasted with this *aa Leaves compound.* Obviously the leaf is simple and the genus sought lies in that portion of the key preceding *aa,* i. e., under *a.* The subdivisions, *b,* and *bb,* under *a* afford you a choice between *Leaves needle-shaped, awl-shaped, strap-shaped or scale-like* and *Leaves broad and flat.* The leaf being broad and flat you pass onwards in the key to *c* and *cc* under *bb.* Here you have a choice between *Leaves alternate or clustered* and *Leaves opposite.* Inspection shows the arrangement to be alternate, and you know that the genus sought lies in that portion of the key which lies between *c* and *cc.* Passing to *d* and *dd* under *c* you are offered the choice between *Margin of leaves entire or only slightly undulate* and *Margin of leaves serrate, toothed or lobed* and your observation clearly indicates that the leaf is neither entire nor undulate, hence are in *dd* class. Under *dd* you may choose between *e, Margin of leaves serrate to toothed* and *ee, Margin of leaves distinctly lobed.* The leaf being deeply lobed, you know that the genus sought is one of five lying between *ee* and *cc,* all of which have lobed leaves. To make the determination, you must look for the fruit, since *f* and *ff* under *ee* give a choice between *Fruit an acorn* and *Fruit not an acorn.* You poke about in the grass beneath the tree with your foot, finding an acorn, water-soaked and worm-eaten, and then another. But these may have been carried hither by an industrious squirrel or washed here by the rain or blown by the wind and deposited for the entrapment of the unwary. Hence you look up into the tree for affirmation and observing more closely than heretofore you note that the young, green acorns are quite apparent. The genus, then, is *Quercus.*

Before going further in your pursuit it will be well for you to go back over the key to make careful note of the particular characters which were used to separate this genus from the other genera and to try to fix these in mind. This being done, you should turn to the page indicated, where you will find a *Summer Key to the Species of Quercus.* You may then run through this key in the same manner that you did the genus key. If you have been careful in your search you will stop finally at *Quercus alba.* At this point you will do well once more to pause and go back over this key and try to fix in mind the characters which were used to separate the various species, especially the difference between your tree and *Quercus macrocarpa,* which it resembles so closely. This done, you will turn to the page indicated and compare the characters of your tree with the drawings and descriptions. If you are satisfied with your diagnosis, well and good. If you find that you are wrong, go over the keys again and find wherein you were led astray.

Before you leave the tree take a sample of leaf properly labeled which you can press between the pages of an old magazine and save for future reference. Do this with other trees which you may find and when you get home lay them out side by side so that the labels will not show and compare them. A few trials of this kind will serve to form a mental picture of each leaf which you will remember.

A very helpful practice for the beginner is that of making keys based upon various characters. Practice keys of this kind will bring out the differences and likenesses of trees as will no other means, and characters which hitherto have escaped the eye will be brought forward prominently. Nor should the student take his characters from books, but rather should go to the woods and get his knowledge at first hand.

It is hardly necessary to state that while the key is a valuable crutch while learning to walk, once the leg is strong enough to bear the weight it should be discarded, lest it becomes a burden. A key's main function is the guidance of the student through the preliminary steps leading to a more intimate knowledge of the trees.

SUMMER KEY TO THE GENERA

a. Leaves simple.
  b. Leaves needle-shaped, awl-shaped, strap-shaped or scale-like.
    c. Leaves in clusters of 2-many.
      d. Leaves in clusters of 2-5 sheathed, persistent for several years .... **Pinus,** p. 25.
      dd. Leaves in fascicles of 8-many, on short, lateral branchlets, deciduous in autumn.................. **Larix,** p. 35.
    cc. Leaves solitary, not clustered.
      d. Leaves opposite.
        e. Twigs flattened; leaves all of one kind, scale-like, decurrent on the stem; fruit a small, pale brown cone, **Thuja,** p. 51.
        ee. Twigs essentially terete; leaves of two kinds, either scale-like, or else awl-shaped, often both kinds on the same branch, not decurrent on the stem; fruit berry-like, bluish .... **Juniperus,** p. 53.
      dd. Leaves alternate or spirally-whorled.
        e. Leaves flattened, soft to the touch.
          f. Leaves ½-1¼ inches long, sessile, aromatic; cones 2-4 inches long; bark of trunk with raised blisters containing resin .... **Abies,** p. 47.
          ff. Leaves seldom over ½ inch long, short-petioled, not aromatic; cones about ¾ inch long; bark of trunk without raised blisters .... **Tsuga,** p. 49.
        ee. Leaves 4-sided, harsh to the touch........ **Picea,** p. 37.
  bb. Leaves broad and flat.
    c. Leaves alternate or clustered, never opposite.
      d. Margin of leaves entire or only slightly undulate.
        e. Leaves 2-5 inches long; fruit a drupe or berry, **Nyssa,** p. 183.
        ee. Leaves 5-9 inches long; fruit an acorn.. **Quercus,** p. 112.
      dd. Margin of leaves serrate, toothed or lobed.
        e. Margin of leaves serrate to toothed.
          f. Branches armed with stiff, sharp thorns, **Crataegus,** p. 147.

ff. Branches not armed.
  g. Base of leaves decidedly oblique.
    h. Leaf-blades about as long as they are broad, heart-shaped; fruit globose, woody, ripe in autumn, **Tilia,** p. 181.
    hh. Leaf-blades 1½-2 times as long as they are broad, oval to ovate; fruit a membranaceous samara, ripe in spring .... **Ulmus,** p. 129.
  gg. Base of leaves essentially symmetrical.
    h. Teeth coarse, 2-5 per inch of margin.
      i. Leaves very glabrous both sides; fruit a prickly bur.
        j. Leaves 3-5 inches long, very lustrous beneath; bark close, smooth, steel-gray.. **Fagus,** p. 107.
        jj. Leaves 6-8 inches long, not lustrous beneath; bark fissured, brownish.... **Castanea,** p. 108.
      ii. Leaves pubescent or white-tomentose, at least beneath; fruit not a prickly bur.
        j. Leaves 2-4 inches long, broadly ovate to sub-orbicular; fruit a very small capsule, falling in spring .... **Populus,** p. 60.
        jj. Leaves 4-7 inches long, oblong-lanceolate to obovate; fruit an acorn, falling in autumn, **Quercus,** p. 112.
    hh. Teeth fine, 6-many per inch of margin.
      i. Leaf-petioles laterally compressed; leaves tremulous .... **Populus,** p. 60.
      ii. Leaf-petioles terete; leaves not tremulous.
        j. Leaf-blades at least 3 times as long as they are broad.
          k. Twigs brittle; fruit a very small capsule, falling in spring .... **Salix,** p. 55.
          kk. Twigs tough; fruit a fleshy drupe, falling in late summer or autumn.... **Prunus,** p. 149.
        jj. Leaf-blades not more than twice as long as they are broad.
          k. Leaf-blades about twice as long as they are broad.
            l. Margin of leaves singly serrate; fruit fleshy.

m. Lenticels conspicuous; pith whitish or brownish; bark easily peeled off in papery layers; buds ovoid,
Prunus, p. 149.

mm. Lenticels inconspicuous; pith greenish: bark not separable into papery layers; buds narrow-conical,
Amelanchier, p. 145.

ll. Margin of leaves doubly serrate; fruit not fleshy.

m. Trunk fluted; fruit inclosed within a halberd-shaped involucre,
Carpinus, p. 95.

mm. Trunk not fluted; fruit not inclosed within a halberd-shaped involucre.

n. Bark of trunk gray-brown, broken into narrow, flattish pieces loose at the ends; fruit in hop-like strobiles,
Ostrya, p. 93.

nn. Bark of trunk white, yellow or dark brown, platy or cleaving off in papery layers; fruit not in hop-like strobiles ....**Betula,** p. 97.

kk. Leaf-blades almost as broad as they are long.

l. Lower side of leaves more or less downy; sap milky; leaves not crowded on short, spur-like branchlets; fruit berry-like, black ....**Morus,** p. 137.

ll. Lower side of leaves glabrous; sap not milky; leaves crowded on short, spur-like branchlets; fruit a large, green pome,
Pyrus, p. 143.

ee. Margin of leaves distinctly lobed.

f. Fruit an acorn.....................**Quercus,** p. 112.

ff. Fruit not an acorn.

g. Leaf-lobes entire; leaves lustrous above, their petioles 5-6 inches long......**Liriodendron,** p. 139.

gg. Leaf-lobes sinuate-toothed to serrate; leaves not lustrous above, their petioles 1-2 inches long.
  h. Leaf-lobes coarsely sinuate-toothed; winter-buds forming in summer within the petiole of the leaf, **Platanus,** p. 141.
  hh. Leaf-lobes serrate; winter-buds not forming in summer within the petiole of the leaf.
    i. Branches armed with stiff, sharp thorns; sap not milky .... **Crataegus,** p. 147.
    ii. Branches unarmed; sap milky,... **Morus,** p. 137.

cc. Leaves opposite............................. **Acer,** p. 162.

aa. Leaves compound.
  b. Leaves alternate.
    c. Branchlets armed with short, sharp prickles.. **Robinia,** p. 159.
    cc. Branchlets unarmed.
      d. Upper leaflets less than 1 inch broad; fruit berry-like, ¼ inch in diameter .... **Pyrus,** p. 143.
      dd. Upper leaflets 1-5 inches broad; fruit a nut an inch or more in diameter.
        e. Leaflets 5-11; pith homogeneous.......... **Carya,** p. 83.
        ee. Leaflets 11-23; pith chambered.......... **Juglans,** p. 77.
  bb. Leaves opposite.
    c. Leaves pinnately compound; fruit a samara.
      d. Leaflets 3-5; samaras paired............... **Acer,** p. 162.
      dd. Leaflets 7-11, exceptionally 5; samaras not paired, **Fraxinus,** p. 185.
    c. Leaves digitately compound; fruit a prickly bur, **Aesculus,** p. 179.

WINTER KEY TO THE GENERA

a. Leaves persistent and green through the winter, needle-shaped, awl-shaped or scale-like.

b. Leaves in clusters of 2-5, sheathed............... **Pinus,** p. 25.

bb. Leaves solitary, not clustered.

c. Leaves opposite.

d. Twigs flattened; leaves all of one kind, scale-like, decurrent on the stem; fruit a small pale brown cone..**Thuja,** p. 51.

dd. Twigs essentially terete; leaves of two kinds, either scale-like, or else awl-shaped, often both kinds on the same branch, not decurrent on the stem; fruit berry-like, bluish, **Juniperus,** p. 53.

cc. Leaves alternate or spirally-whorled.

d. Leaves flattened, soft to the touch.

e. Leaves ½-1¼ inches long, sessile, aromatic; cones 2-4 inches long; bark of trunk with raised blisters containing resin .... **Abies,** p. 47.

ee. Leaves seldom over ½ inch long, short-petioled, not aromatic; cones about ¾ inch long; bark of trunk without raised blisters .... **Tsuga,** p. 49.

dd. Leaves 4-sided, harsh to the touch............ **Picea,** p. 37.

aa. Leaves not persistent and green throughout the winter, but deciduous in early autumn.

b. Twigs, branches or trunks armed with stiff, sharp spines or thorns.

c. Thorns or spines not exceeding ½ inch in length on the branches, in pairs at each node; buds rusty-hairy, 3-4 superposed; fruit a flat pod .... **Robinia,** p. 159.

cc. Thorns or spines much exceeding ½ inch in length on the branches, not in pairs at each node; buds not rusty-hairy, not superposed; fruit a pome .... **Crataegus,** p. 147.

bb. Twigs, branches or trunks unarmed.

c. Leaf-scars mainly crowded on short, stout, lateral shoots; bundle-scar 1; fruit a cone .... **Larix,** p. 35.

cc. Leaf-scars distributed along the lateral branches; bundle-scars 3-many; fruit not a cone.

d. Leaf-scars 2 at a node, i. e., opposite.

e. Terminal buds ½-1½ inches long, resin-coated; twigs very stout .... **Aesculus,** p. 179.

ee. Terminal buds rarely exceeding ½ inch in length, not resin-coated; twigs not conspicuously stout.

f. Bundle-scars usually 3, distinct, separated . **Acer,** p. 163.

ff. Bundle-scars many, minute, more or less confluent in a U-shaped line .... **Fraxinus,** p. 185.

dd. Leaf-scars 1 at a node, i. e., alternate.

e. Bundle-scars 3 or in 3 compound, but distinct groups.

f. Terminal bud present.

g. Stipule-scars present.

h. First scale of lateral bud directly in front, i. e., exactly above the center of the leaf-scar; twigs brittle; pith somewhat star-shaped in cross-section .... **Populus,** p. 61.

hh. First scale of lateral bud not directly in front, i. e., to one side of the center of the leaf-scar; twigs not brittle; pith circular in cross-section, **Prunus,** p. 149.

gg. Stipule-scars absent.

h. Buds bright to dark red, the terminal ⅛-¼ inch long .... **Nyssa,** p. 183.

hh. Buds brownish to gray, the terminal exceeding ¼ inch in length.

i. Buds narrow-conical, sharp-pointed; leaf-scars small, narrowly crescent-shaped; twigs about 1/16 inch thick; pith homogeneous; fruit berry-like, not present............. **Amelanchier,** p. 145.

ii. Buds broadly conical to ovoid, blunt-pointed; leaf-scars conspicuous, broadly heart-shaped; twigs about ¼ inch thick; pith chambered; fruit a nut, often present........... **Juglans,** p. 77.

ff. Terminal bud absent (sometimes present on short shoots of *Betula*).

g. Stipule-scars present.

h. Bud-scale only 1 visible; twigs brittle, **Salix,** p. 55.

hh. Bud-scales 2 or more; twigs not brittle.

i. Bark smooth, close, warty or peeling off in papery layers, but not flaky nor rough-ridged.

j. Trunk fluted; catkins not present in winter; lenticels not elongated horizontally; low tree or bushy shrub .... **Carpinus,** p. 95.

jj. Trunk not fluted; catkins usually present in winter; lenticels elongated horizontally; large trees ....**Betula,** p. 97.

ii. Bark flaky or rough-ridged, not warty nor peeling off in papery layers.

j. Bundle-scars depressed, conspicuous; bark thick, more or less deeply furrowed, **Ulmus,** p. 129.

jj. Bundle-scars not depressed, inconspicuous; bark thin, broken into narrow, flattish strips, loose at the ends.............**Ostrya,** p. 93.

gg. Stipule-scars absent................**Prunus,** p. 149.

ee. Bundle-scars 4-many.

f. Bundle-scars in a single U-shaped line.

g. Terminal bud present; fruit berry-like; a shrub or small tree ....**Pyrus,** p. 143.

gg. Terminal bud absent; fruit not berry-like; large trees.

h. Stipule-scars encircling the twig; leaf-scars nearly surrounding the bud; bark peeling off in thin plates, exposing the lighter colored inner bark, **Platanus,** p. 141.

hh. Stipule-scars not encircling the twig; leaf-scars not nearly surrounding the bud; bark thick, rough-ridged, not exposing the inner bark, **Ulmus,** p. 129.

ff. Bundle-scars variously grouped or scattered, but not in a single line.

g. Terminal bud present.

h. Stipule-scars present.

i. Stipule-scars encircling the twig; visible bud-scales 2, united....... **Liriodendron,** p. 139.

ii. Stipule-scars not encircling the twig; visible bud-scales more than 2, not united.

j. Buds 4 times as long as broad, not clustered at the tips of vigorous shoots; fruit a prickly bur ....**Fagus,** p. 107.

jj. Buds not 4 times as long as broad, usually clustered at the tips of vigorous shoots; fruit an acorn ....**Quercus,** p. 113.

hh. Stipule-scars absent ....**Carya,** p. 83.

gg. Terminal bud absent (occasionally present in *Castanea*).

h. Bud at end of twig very obliquely unsymmetrical, mucilaginous when chewed........**Tilia,** p. 181.

hh. Bud at end of twig symmetrical, not mucilaginous when chewed.

i. Bud-scales 2-3 visible; pith star-shaped in cross-section; sap not milky; fruit a prickly bur, present; large tree ....**Castanea,** p. 108.

ii. Bud-scales 4-8 visible; pith not star-shaped in cross-section; sap milky; fruit berry-like, not present; small tree............**Morus,** p. 137.

PINACEAE—PINE FAMILY

THE PINES

The pines are the largest and most useful group of trees included in the great cone-bearing family. There are nine different species in the eastern United States, four of which are found in Vermont.

The pines, like the other members of this family, produce their seeds in cones. They are peculiar, however, in that their cones require two years for maturing. The flowers also take the form of cones, the pollen-bearing and the ovule-bearing clusters being separated, though both may be found on the same tree. The yellow pollen matures in May or June, when it is scattered in great abundance, to be borne to its destination by the wind. Most of the seed-bearing cones develop on the upper branches, and the nut-like seeds escape from them during the second autumn. The empty cones with opened scales thereafter may cling to the tree for some time or they may fall soon.

The leaves of all the evergreens cling to the branches several years. The leaves of the white pine, for example, drop when they are three or four years old. The arrangement of the leaves, or needles, in clusters of from two to five, with the base of each cluster encased in a delicate sheath, offers a simple means of distinguishing the species.

Introduced species.—Two European pines, the Austrian and the Scotch, are often planted in Vermont as forest trees as well as for ornamental purposes. The Scotch pine has leaves two in a cluster, 2-4 inches long, flat and of a bluish-white hue. The Austrian pine has dark green, slender, rigid leaves, two in a cluster, 4-6 inches long.

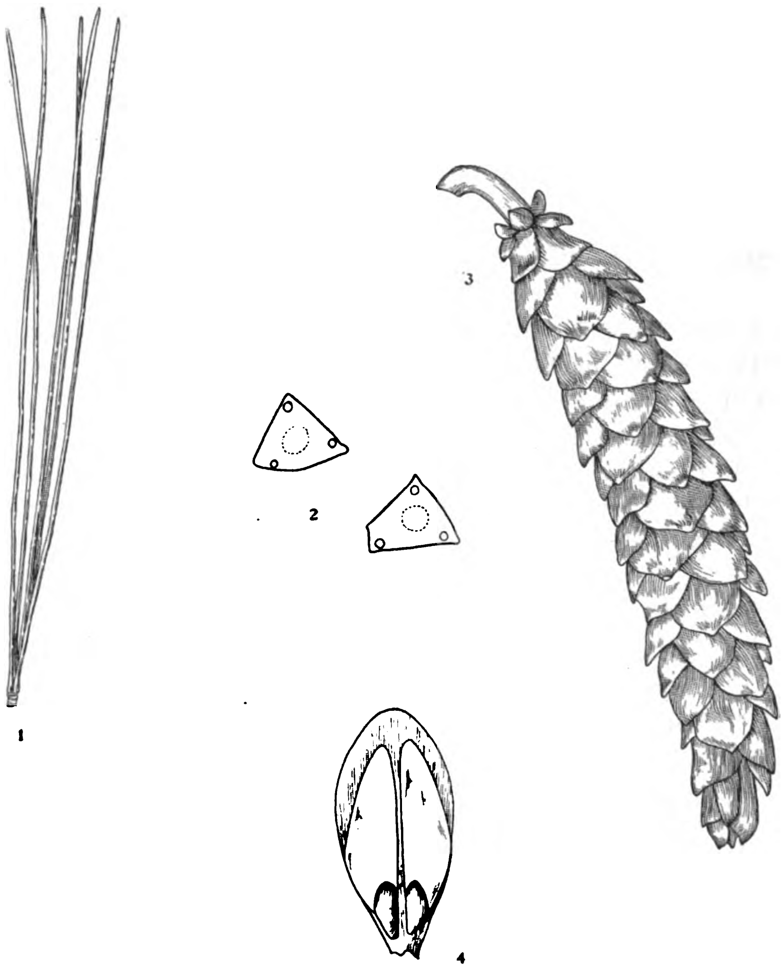
SUMMER AND WINTER KEY TO THE SPECIES OF PINUS

a. Leaves 5 in a cluster; cones 4-10 inches long ....**P. strobus,** p. 27.

aa. Leaves not 5 in a cluster; cones less than 4 inches long.

- *b.* Leaves 2 in a cluster; cone-scales unarmed, or at most provided with minute prickles.
  - *c.* Leaves less than 4 inches long (about 1 inch), strongly divergent; cones pointing forward towards the tip of the branch, persistent 10-15 years, opening very unevenly, **P. banksiana,** p. 31.
  - *cc.* Leaves 4-6 inches long, not strongly divergent; cones not pointing forward towards the tip of the branch, not persistent 10-15 years, but opening in the autumn of the second season and falling the next summer ....**P. resinosa,** p. 33.
- *bb.* Leaves 3 in a cluster; cone-scales armed with conspicuous prickles ....**P. rigida,** p. 29.

White Pine



(Mich. Trees).

1. Cluster of leaves, x 1.
2. Cross-sections of leaves, enlarged.
3. Partly opened cone, x ¾.
4. Cone-scale with seeds, x 1.

PINACEAE

White Pine

Pinus strobus L.

HABIT.—A large tree 60-80 feet high, with a trunk diameter of 2-4 feet; forming a wide, pyramidal crown. Formerly trees 100-150 feet in height and 5-7 feet in trunk diameter were not exceptional.

LEAVES.—In clusters of five; 3-5 inches long; slender, straight, needle-shaped, 3-sided, mucronate; pale blue-green. Persistent about 2 years.

FLOWERS.—June; monoecious; the staminate oval, light brown, about ⅓ inch long, surrounded by 6-8 involucral bracts; the pistillate cylindrical, about ¼ inch long, pinkish purple, long-stalked.

FRUIT.—Autumn of second season, falling during the winter and succeeding spring; pendent, short-stalked, narrow-cylindrical, often curved, greenish cones, 4-10 inches long; scales rather loose, slightly thickened at the apex; seeds red-brown, ¼ inch long, with wings 1 inch long.

WINTER-BUDS.—Oblong-ovoid, sharp-pointed, yellow-brown, ¼-½ inch long.

BARK.—Twigs at first rusty-tomentose, later smooth and light brown, finally thin, smooth, greenish; thick, dark gray on the trunk, shallowly fissured into broad, scaly ridges. Plate I.

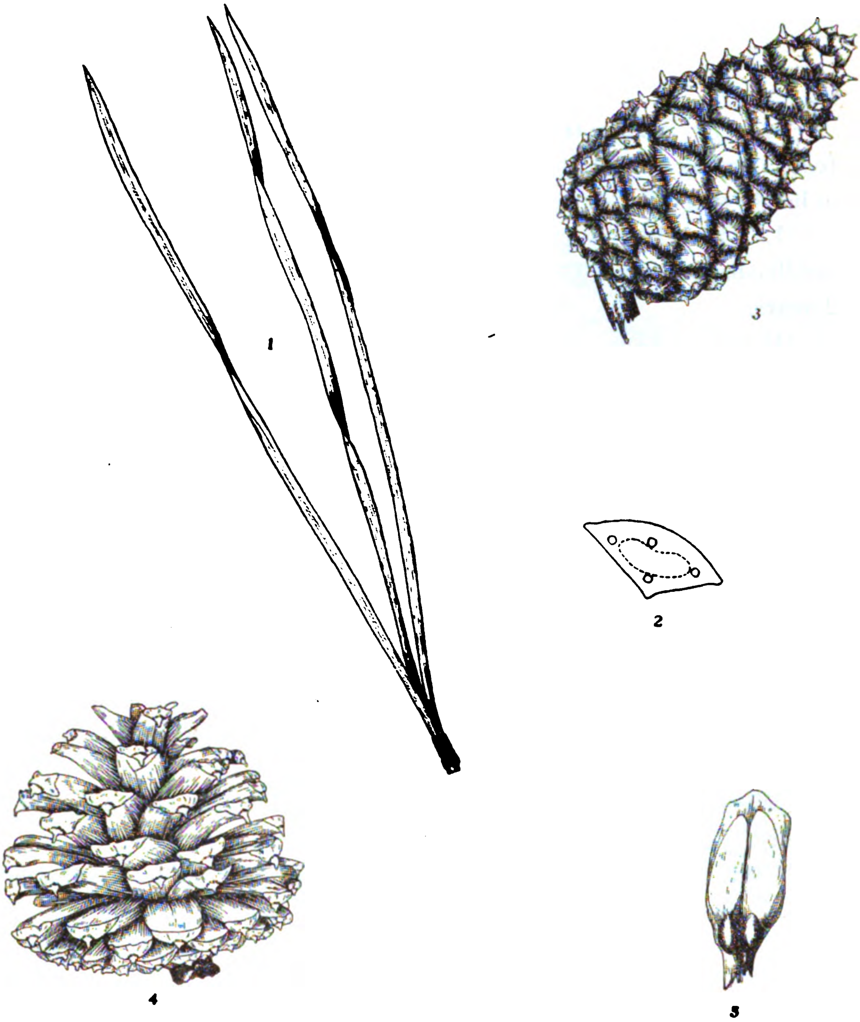
WOOD.—Light, soft, weak, compact, straight-grained, easily worked, light brown, with thin, whitish sapwood. Page 215.

DISTRIBUTION.—Common throughout the state up to 1,000 feet altitude, but most abundant in the Champlain and Connecticut valleys.

HABITAT.—Prefers a light, fertile loam; sandy soils of granite origin.

NOTES.—The white pine, growing as it does sometimes to immense height, was one of the loftiest trees of the primeval New England forest. Lumbermen have removed most of the patriarchs and only the younger trees commonly remain. Its slender lustrous leaves are borne in close clusters and give it a beauty and delicacy of foliage possessed by no other pine. It is one of the most valuable and most rapidly growing of Vermont's timber trees and is being planted every year by the thousands in our state forests and by private owners.

Pitch Pine



1. Cluster of leaves, x 1.
2. Cross-section of leaf, enlarged.
3. Unopened cone, x 1.
4. Opened cone, x 1.
5. Cone-scale with seeds, x 1.

PINACEAE

Pitch Pine

Pinus rigida Mill.

HABIT.—A small tree 40-60 feet high, with a short, crooked trunk 1-2 feet in diameter; coarse, gnarled branches form an irregular, open, pyramidal or rounded crown; a decidedly scraggly tree.

LEAVES.—In clusters of three; 2-5 inches long; stout, stiff, tapering to a thick tip; more or less twisted, divergent from a short sheath; bright yellow-green. Persistent 2-3 years.

FLOWERS.—May-June; monoecious; the staminate in short, crowded, cylindrical spikes about ¾ inch long, yellowish; the pistillate lateral, subglobose, short-stalked, more or less clustered, reddish-green, about ⅛ inch long.

FRUIT.—Autumn of second season, opening soon after, but persistent on the tree for 10-12 years; lateral, at about a right angle to the branch, either solitary or in whorls of several; ovoid to nearly globose, nearly sessile cones 1-3 inches long; scales thickened at the apex and armed with a stiff, recurved prickle; seeds triangular, dark brown, ¼ inch long, with wings about ½ inch long.

WINTER-BUDS.—Cylindrical to ovoid, sharp-pointed, dark red-brown, about ½ inch long.

BARK.—Twigs smooth, light green, becoming yellow, finally dark gray-brown and rough with the persistent bases of fallen leaves; thin, red-brown on the trunk, with broad, flat ridges and deepish furrows. Plate I.

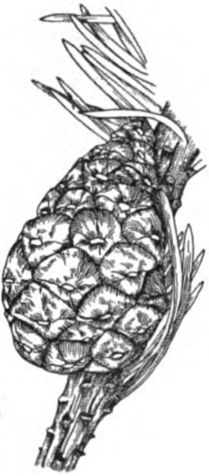
WOOD.—Light, soft, weak, brittle, coarse-grained, very durable, light brown or red, with thick, yellowish to whitish sapwood.

DISTRIBUTION.—Common in the northern portion of the Champlain Valley, especially along the lower courses of the Winooski, Lamoille and Missisquoi Rivers; less common in the Connecticut Valley as far north as Wells River.

HABITAT.—Barren, sandy soil.

NOTES.—This tree is a prolific seeder. It is able to sprout from the stump and is fire-resistant. In suitable places it forms dense groves of small trees, forty to sixty feet in height. The individual trees sometimes are picturesque but neither graceful nor very attractive in appearance. The branches even of the smaller trees mature numerous cones, which are long persistent. They are about two inches long, and, as has been said, they have scales tipped with sharp recurved prickles, a character which may aid in its recognition.

Gray Pine. Jack Pine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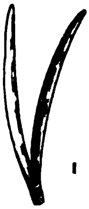
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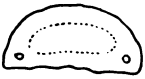
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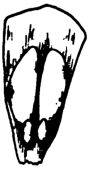
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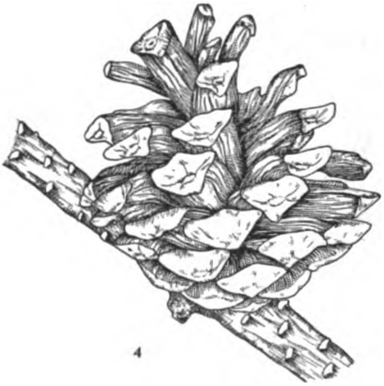
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(Mich. Trees).

1. Cluster of leaves, x 1.
2. Cross-section of leaf, enlarged.
3. Branchlet with unopened cone, x 1.
4. Branchlet with opened cone, x 1.
5. Cone-scale with seeds, x 1.

PINACEAE

Gray Pine. Jack Pine

Pinus banksiana Lamb. [Pinus divaricata (Ait.) DuMont de Cours.]

HABIT.—Usually a small tree 15-30 feet high, with a trunk diameter of 8-12 inches; forming usually a scrubby, stunted, and variously distorted crown.

LEAVES.—In clusters of two; about 1 inch long; narrow-linear, with sharp-pointed apex; stout, curved or twisted, divergent from a short sheath; dark gray-green. Persistent 2-3 years.

FLOWERS.—May-June; monoecious; the staminate in oblong clusters ½ inch long, composed of many sessile, yellow anthers imbricated upon a central axis; the pistillate in subglobose clusters, composed of many carpel-like, purple scales (subtended by small bracts) spirally arranged upon a central axis.

FRUIT.—Autumn of second or third season, but remaining closed for several years and persistent on the tree for 10-15 years; erect, usually incurved, oblong-conical, sessile cones, 1½-2 inches long; scales thickened at the apex; seeds triangular, nearly black, ⅜ inch long, with wings ⅓ inch long.

WINTER-BUDS.—Terminal bud ¼ inch long, ovoid, rounded, pale brown; lateral buds smaller.

BARK.—Twigs yellow-green, becoming purple, finally dark red-brown and rough with the persistent bases of fallen leaves; thin, dark red-brown on the trunk, with shallow, rounded ridges, rough-scaly on the surface.

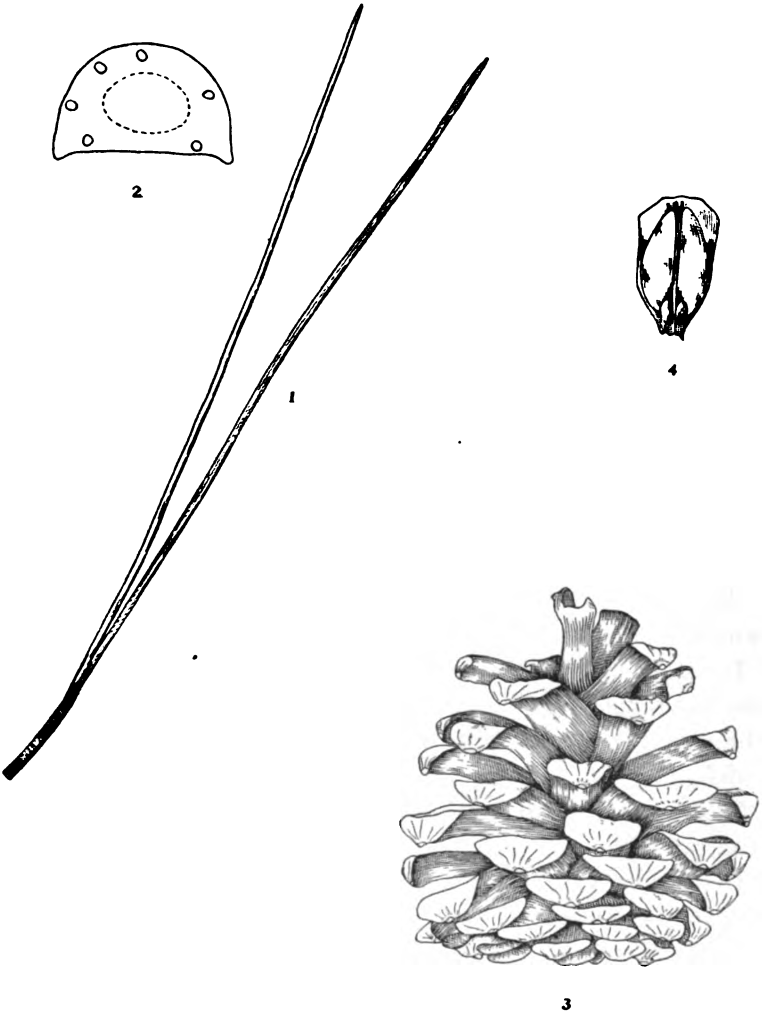
WOOD.—Light, soft, weak, close-grained, light brown, with thick, whitish sapwood.

DISTRIBUTION.—Reported at Monkton and Starksboro in Addison county and at Fairfax in Franklin county; but few trees at each station.

HABITAT.—Sandy, sterile soil; rocky slopes.

NOTES.—The gray pine is the smallest of the Vermont pines, with sprawling habit and short stout leaves, giving the tree a bristly, stunted appearance. Its characteristic cones are pointed and curved toward the main axis of the stem, often partially encircling it. The gray pine is a northern species extending to the Arctic region, and the line of its southeastern limit passes through northern Vermont. It is one of the rarest of our trees, and but few specimens are known to occur within our State borders. The remaining trees should be sought out and spared because of their scientific interest.

Red Pine. Norway Pine



(Mich. Trees).

1. Cluster of leaves, x 1.
2. Cross-section of leaf, enlarged.
3. Opened cone, x 1.
4. Cone-scale with seeds, x 1.

PINACEAE

Red Pine. Norway Pine

Pinus resinosa Ait.

HABIT.—A large tree 50-75 feet high, with a trunk diameter of 2-3 feet; stout, horizontal branches form a broad, rounded, rather open crown.

LEAVES.—In clusters of two; 4-6 inches long; slender, straight, needle-shaped, sharp-pointed, flexible, from elongated, persistent sheaths; lustrous dark green. Persistent 4-5 years.

FLOWERS.—April-May; monoecious; the staminate in oblong, dense clusters, ½-¾ inch long, composed of many sessile, purple anthers imbricated upon a central axis; the pistillate single or few-clustered at the end of the branchlets, subglobose; scales ovate, scarlet, borne on stout peduncles covered with pale brown bracts.

FRUIT.—Autumn of second season, falling the next summer; ovate-conical, nearly sessile cones, about 2 inches long; scales thickened at the apex; seeds oval, compressed, light mottled-brown, with wings ½-¾ inch long.

WINTER-BUDS.—About ¾ inch long, ovoid or conical, acute, red-brown, with rather loose scales.

BARK.—Twigs orange-brown, becoming rough with the persistent bases of leaf-buds; thick and red-brown on the trunk, shallowly fissured into broad, flat ridges. Plate I.

WOOD.—Light, hard, very close-grained, pale red, with thin, yellow to white sapwood. Page 217.

DISTRIBUTION.—Scattered groups or small groves occur on the dry, rocky headlands of Lake Champlain and it may be found in similar soils in the river valleys throughout Vermont, although it is less frequent in the southern counties.

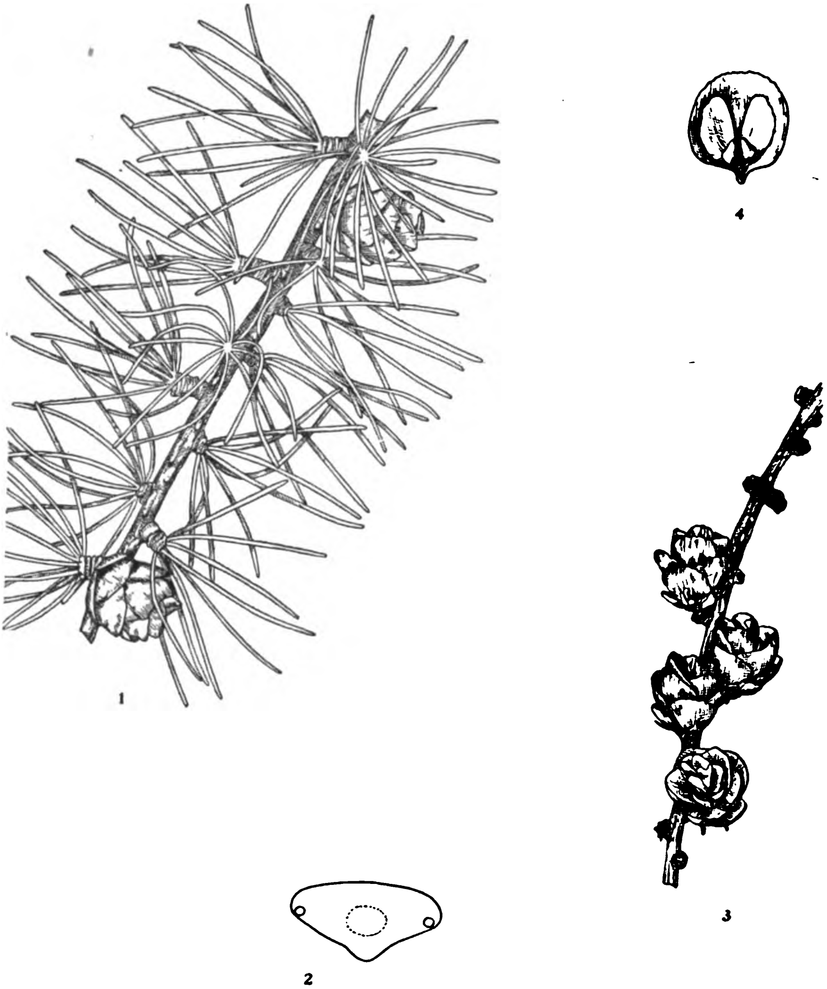
HABITAT.—Poor soils; sandy plains and dry woods.

NOTES.—The red pine makes a rapid growth on our better soils. It is difficult to transplant but should be used extensively.

The name "red pine" is appropriate both because of the pale red color of the heart wood and the distinctly reddish cast of the bark. This species does not grow in Norway or elsewhere in Europe, and it is said that it received the name from the town of Norway, Maine. The name "Norway pine" has so little fitness as applied to this tree, and evidently is so misleading that its use is to be discouraged.

The picturesqueness and individuality of the red pine commend it for wider use as an ornamental tree.

Tamarack



(Mich. Trees).

1. Autumn branchlet, with leaves and cones, x 1.
2. Cross-section of leaf, enlarged.
3. Fruiting branchlet in winter, x 1.
4. Cone-scale with seeds, x 2.

PINACEAE

Tamarack

Larix laricina (DuRoi) Koch [Larix americana Michx.]

HABIT.—A tree sometimes 80-100 feet high, with a trunk diameter of 1-2 feet; forming a broad, open, irregular crown of horizontal branches.

LEAVES.—Scattered singly along the leading shoots or clustered on the short lateral branchlets; linear, with blunt apex; rounded above, keeled beneath; about 1 inch long; bright green; sessile. Deciduous in early autumn.

FLOWERS.—May, with the leaves; monoecious; the staminate sessile, subglobose, yellow, composed of many short-stalked anthers spirally arranged about a central axis; the pistillate oblong, short-stalked, composed of orbicular, green scales (subtended by red bracts) spirally arranged about a central axis.

FRUIT.—Autumn of first season, but persistent on the tree for a year longer; ovoid, obtuse, light brown, short-stalked cones, ½-¾ inch long; seeds ⅛ inch long, with pale brown wings widest near the middle.

WINTER-BUDS.—Small, globose, lustrous, dark red.

BARK.—Twigs at first grayish, glaucous, later light orange-brown, and finally dark brown; red-brown and scaly on the trunk. Plate I.

WOOD.—Heavy, hard, very strong, coarse-grained, very durable, light brown, with thin, nearly white sapwood. Page 219.

DISTRIBUTION.—Common throughout Vermont, except in the lower Connecticut valley.

HABITAT.—Cold, deep swamps.

NOTES.—The tamarack becomes a picturesque tree in old age. It grows slowly in swamps, but rapidly on well-drained soils. It is our only cone-bearing tree which drops its leaves in the autumn. The tamarack is an attractive, conical tree, its graceful form and full clusters of slender, delicate leaves giving it a well-marked individuality. Its deep red, fleshy cones, which open in June, resemble flower clusters.

THE SPRUCES

Every Vermonter should know and appreciate the spruces for the mountain spruce and the sugar maple are our most characteristic trees. The forests of North America contain seven species of spruce, three of which occur in Vermont.[1]

The spruces are northern trees, and Vermont lies rather south of the belt of their most abundant growth in northeastern America. It is therefore our mountain sides and cool swamps which furnish conditions suitable for their best development.

The flowering cones are similar to those of the pine in general characters. The flowers appear in spring and the cones mature the following autumn, the seeds being shed during autumn or early winter.

Until recently botanists considered the two species here described as the red spruce and the black spruce to be simply varieties of one species, to which was given the common name of black spruce. In the lumber trade all three kinds are handled, without discrimination, as "spruce." As a matter of fact, the red spruce furnishes nearly all of the spruce lumber cut in Vermont. Spruce gum also comes chiefly from the red spruce, although it is formed by the other species.

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[1] *Introduced species.*—The Norway spruce (*Picea abies*) is commonly cultivated in Vermont dooryards, parks and cemeteries, and is superior to our native trees for such purposes. It is recognized easily by its more pendulous branches and very large slender cones, five to seven inches long.

The Colorado blue spruce (*P. pungens*) is occasionally planted. This is characterized by its beautiful glaucous-blue foliage. The cones are three to five inches long.

SUMMER AND WINTER KEY TO THE SPECIES OF PICEA

a. Leaves ⅛-⅝ inch long; twigs conspicuously pubescent.

b. Leaves usually ⅛-⅜ inch long, typically blunt-pointed, dark blue-green; cones about 1 inch long, persistent on the branches for many years, their scales ragged-toothed; tree typical of swamps .... **P. mariana,** p. 43.

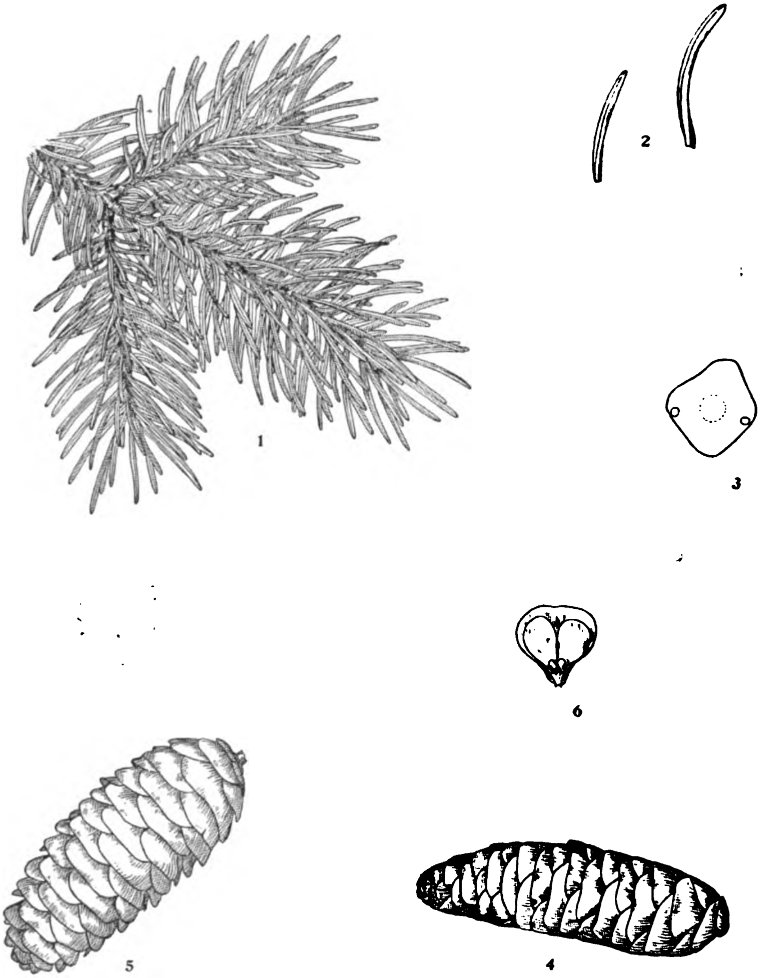
bb. Leaves ⅜-⅝ inch long, typically sharp-pointed, dark yellow-green; cones 1¼-2 inches long, falling mostly during their first winter, their scales not ragged-toothed; tree typical of well-drained uplands and rocky slopes............ **P. rubra,** p. 41.

aa. Leaves ⅝-1 inch long; twigs not conspicuously pubescent, usually glabrous.

b. Cones 1-2 inches long, maturing and falling in first season, their scales not toothed; leaves ill-scented when bruised, **P. canadensis,** p. 39.

bb. Cones 3-6 inches long, maturing and falling in second season, their scales finely toothed; leaves not ill-scented when bruised, **P. abies,** p. 45.

White Spruce



(Mich. Trees).

1. Winter branchlet, x 1.
2. Leaves, x 1.
3. Cross-section of leaf, enlarged.
4. Unopened cone, x 1.
5. Partly opened cone, x 1.
6. Cone-scale with seeds, x 1.

PINACEAE

White Spruce

Picea canadensis (Mill.) BSP. [Picea alba Link]

HABIT.—A tree 70-100 feet high, with a trunk diameter of 1-3 feet; forming a rather broad, open, pyramidal crown.

LEAVES.—Spirally arranged, but crowded on the upper side of the branches by the twisting of those on the under side; awl-shaped, 4-sided, incurved; dark blue-green; about ¾ inch long; ill-scented when bruised. Persistent for several years.

FLOWERS.—May; monoecious; the staminate in oblong-cylindrical, long-stalked clusters, ½-¾ inch long, composed of many spirally arranged, red anthers; the pistillate in oblong-cylindrical clusters, composed of broad, reddish scales (subtended by orbicular bracts) spirally arranged upon a central axis.

FRUIT.—Autumn or early winter of first season, falling soon after discharging the seeds; pendent, slender, oblong-cylindrical, nearly sessile cones, 1-2 inches long; seeds about ⅛ inch long, with large wings oblique at the apex.

WINTER-BUDS.—Broadly ovoid, obtuse, light brown, ⅛-¼ inch long.

BARK.—Twigs smooth, gray-green, becoming orange-brown, finally dark gray-brown; thin, light gray-brown on the trunk, separating into thin, plate-like scales.

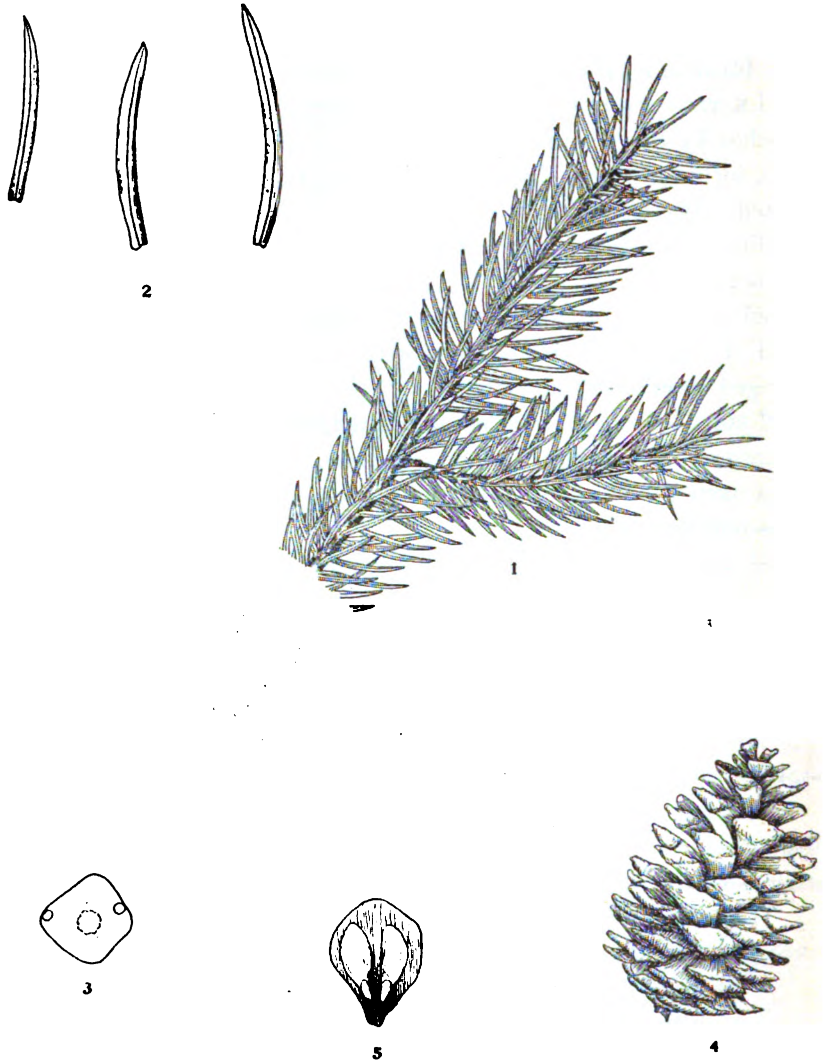
WOOD.—Light, soft, weak, straight-grained, light yellow, with sapwood of the same color.

DISTRIBUTION.—Common in the northeastern quarter of Vermont; also on some of the islands of Lake Champlain; has been reported from other isolated districts.

HABITAT.—Low, damp woods; banks of streams; borders of lakes; high, rocky or sandy slopes.

NOTES.—This is a northern tree which extends from Canada into northern Vermont. It occurs along the Connecticut river to the Fifteen Mile Falls (South Lunenburg), and on the eastern arm of the Y of the Green Mountains to the Montpelier and Wells River railroad, or perhaps a little farther south. It is common on some of the islands of Lake Champlain and is scattered through the forests of Essex county. The strong polecat odor of the young branches is characteristic and will aid in its recognition. Because of this odor it is sometimes called "skunk spruce." Lumbermen do not separate this from the other spruces and the tree is nearly equal in size to the red spruce.

Red Spruce



1. Winter branchlet, x 1.
2. Leaves, x 2.
3. Cross-section of leaf, enlarged.
4. Opened cone, x 1.
5. Cone-scale with seeds, x 1.

PINACEAE

Red Spruce

Picea rubra (DuRoi) Dietr. [Picea rubens Sarg.]

HABIT.—A tree 50-80 feet high, with a trunk diameter of 1-3 feet; forming a narrow, conical crown of slender, spreading branches reaching nearly to the ground; when crowded, usually lacking branches for much of its length.

LEAVES.—Spirally arranged, pointing outward in all directions; awl-shaped, 4-sided, mostly sharp or thickly taper-pointed, more or less incurved; slender; lustrous, dark yellow-green; ⅜-⅝ inch long. Persistent for several years.

FLOWERS.—May; monoecious; the staminate in ovoid clusters, about ½ inch long, composed of many spirally arranged, bright red anthers; the pistillate in oblong-cylindrical clusters, ¾ inch long, composed of thin, rounded, purple scales (subtended by small, obovate bracts) spirally arranged upon a central axis.

FRUIT.—Autumn of first season, falling mostly during their first winter; pendent, elongate-ovoid, short-stalked cones, 1¼-2 inches long; seeds about ⅛ inch long, dark brown, with short, broad wings.

WINTER-BUDS.—Ovoid, acute, light red-brown, puberulous, about 3/16 inch long.

BARK.—Twigs at first greenish, with dense, whitish pubescence, becoming light brown and rusty-pubescent; thin, red-brown on the trunk, flaky with thin scales.

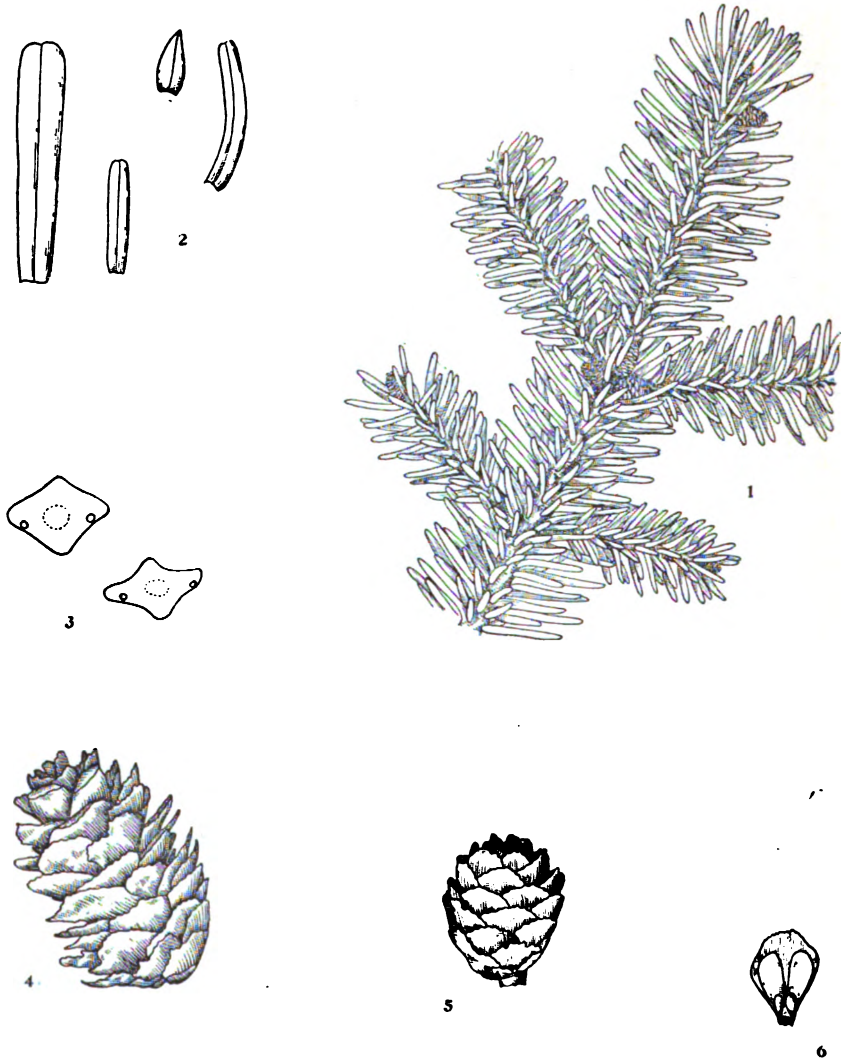
WOOD.—Light, soft, weak, close-grained, pale and tinged with red, with thin, paler sapwood. Page 217.

DISTRIBUTION.—Common throughout Vermont especially on the mountain slopes.

HABITAT.—Well-drained uplands; rocky slopes with thin soil; sometimes extending down to the borders of swamps.

NOTES.—This is the common spruce of our mountain forests, the vast green expanse of which suggested the names of both mountain range and State. It is not distinguished commonly from the preceding species and both are known as "black spruce." It attains a height of from seventy to one hundred feet and large logs may be three or more feet in diameter. When growing in open fields it often forms a conical head with the branches, especially of the younger trees, brushing the ground. It frequently is planted as an ornamental tree in Vermont, but its slower growth and less symmetrical form make it less desirable for this purpose than the native white spruce or Norway spruce.

Swamp Spruce. Black Spruce



(Mich. Trees).

1. **Winter branchlet, x 1.**
2. **Leaves, x 2.**
3. **Cross-sections of leaves, enlarged.**
4-5. **Opened cones, x 1.**
6. **Cone-scale with seeds, x 1.**

PINACEAE

Swamp Spruce. Black Spruce

Picea mariana (Mill.) BSP. [Picea nigra Link]

HABIT.—A small tree 20-50 feet high, with a trunk diameter of 6-12 inches; forming a narrow-based, conical, more or less irregular crown of short, slender, horizontal branches; often small and stunted.

LEAVES.—Spirally arranged, spreading in all directions; awl-shaped, 4-sided, blunt at the apex, more or less incurved; stiff; dark blue-green and glaucous; ⅛-⅜ inch long. Persistent for several years.

FLOWERS.—May; monoecious; the staminate in subglobose clusters, about ½ inch long, composed of many spirally arranged, dark red anthers; the pistillate in oblong-cylindrical clusters, composed of broad, purple scales (subtended by rounded, toothed, purple bracts) spirally arranged upon a central axis, about ½ inch long.

FRUIT.—Autumn of first season, but persistent on the branch for many years; pendent, ovoid, short-stalked cones, about 1 inch long; seeds about ⅛ inch long, with pale brown wings ½ inch long.

WINTER-BUDS.—Ovoid, acute, light red-brown, puberulous, ⅛ inch long.

BARK.—Twigs at first green and rusty-pubescent, becoming dull red-brown and rusty-pubescent; thin, gray-brown on the trunk, separating into thin, appressed scales.

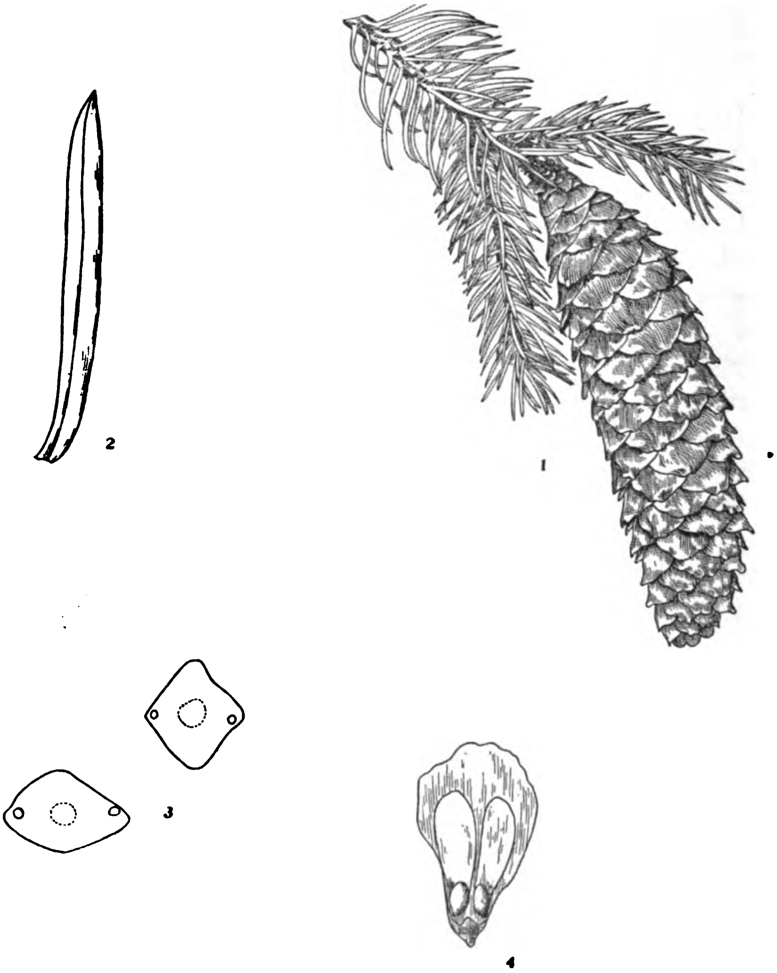
WOOD.—Light, soft, weak, pale yellow-white, with thin, pure white sapwood.

DISTRIBUTION.—This is the common spruce of the sphagnum (peat moss) swamps of the Champlain valley. It is also common in Essex and Franklin counties and probably occurs similarly in the other parts of Vermont, especially in peat bogs, but the distribution is not well known because of its confusion until recently with the red spruce.

HABITAT.—Cold, sphagnous bogs and swamps; shores of lakes.

NOTES.—The black spruce is short-lived. It is undesirable for ornamental planting, as the lower branches die early, making an unattractive evergreen. A small, semi-prostrate, sterile form, *Picea mariana, forma semiprostrata,* occurs on the summit of Mt. Mansfield.

Norway Spruce



(Mich. Trees).

1. Branchlet with partly opened cone, x½.
2. Leaf, x 3.
3. Cross-sections of leaves, enlarged.
4. Cone-scale with seeds, x 1.

PINACEAE

Norway Spruce

Picea abies (L.) Karst. [Picea excelsa Link]

HABIT.—A tree 50-70 feet high, with a trunk diameter of 1-3 feet; forming a dense, conical, spire-topped crown of numerous, drooping branches which persist nearly to the ground.

LEAVES.—Spirally arranged along the twig; crowded; ¾-1 inch long; rigid, curved, acute; lustrous, dark green. Persistent 5-7 years.

FLOWERS.—May; monoecious; the staminate in ovoid to subglobose clusters, long-stalked, reddish to yellowish, ¾-1 inch long; the pistillate in cylindrical clusters, sessile, erect, 1½-2 inches long.

FRUIT.—Autumn of second season; sessile, cylindrical cones 3-6 inches long, pendent from the tips of the uppermost branches; sterile scales very short, toothed; seeds red-brown, rough, ⅛ inch long, with long wings.

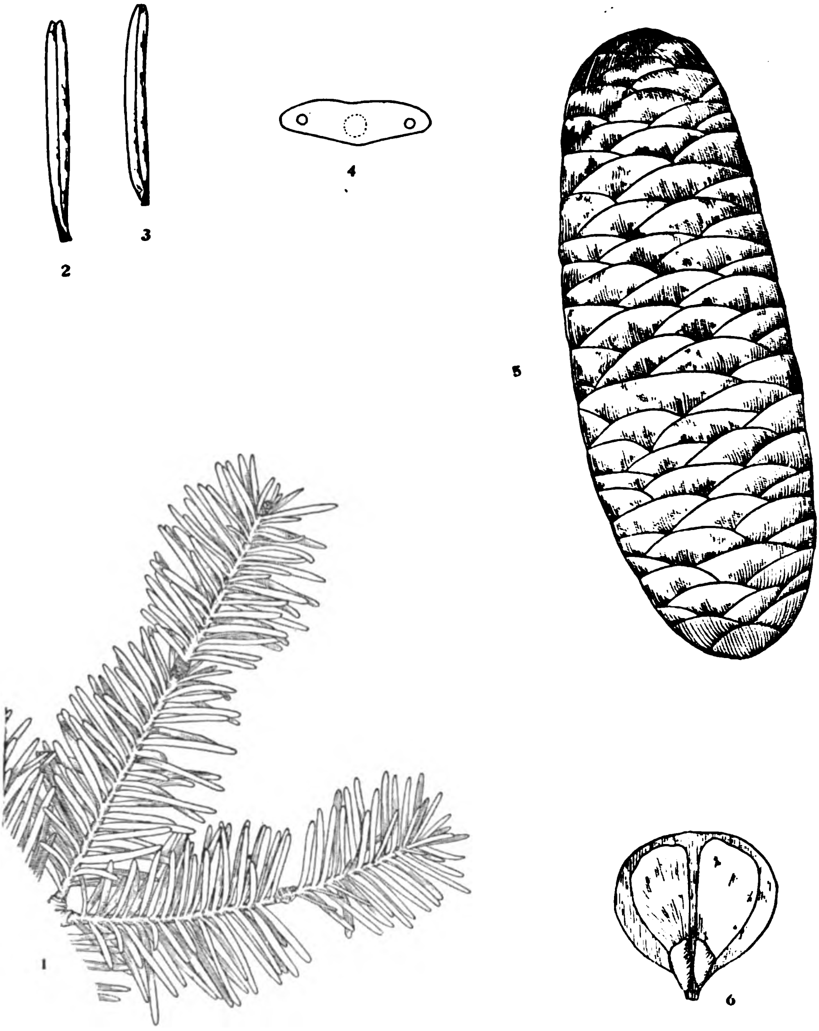
WINTER-BUDS.—Ovoid, acute, red-brown, not resinous, about ⅜ inch long.

BARK.—Twigs red- or orange-brown, smooth or corrugated; becoming thin and gray-brown on old trunks, slightly fissured, scaly.

WOOD.—Light, strong, tough, elastic, soft, fined-grained, white, with thick, indistinguishable sapwood.

NOTES.—This tree is native throughout northern Europe and Asia where it grows to a height of 120 to 150 feet. It is perfectly hardy here and is the common spruce found in dooryards throughout Vermont. As it adapts itself to a variety of soils and climates and grows rapidly, it is especially desirable for ornamental planting, hedges and windbreaks. One of the best known plantations of this spruce is a small area on the Billings estate at Woodstock, which was planted nearly 40 years ago.

Balsam Fir



(Mich. Trees).

1. Winter branchlet, x 1.
2-3. Leaves, x 2.
4. Cross-section of leaf, enlarged.
5. Unopened cone, x 1.
6. Cone-scale with seeds, x 1.

PINACEAE

Balsam Fir

Abies balsamea (L.) Mill.

HABIT.—A slender tree 40-60 feet high, with a trunk diameter of 12-18 inches; branches in whorls of 4-6, forming a symmetrical, open crown widest at the base and tapering regularly upward.

LEAVES.—Scattered, spirally arranged in rows, on young trees at right angles to the branch, on old trees covering the upper side of the branch; narrowly linear, with apex acute or rounded; ½-1¼ inches long; lustrous, dark green above, pale beneath; sessile; aromatic. Persistent 8-10 years.

FLOWERS.—May; monoecious; the staminate oblong-cylindrical, yellow, ¼ inch long, composed of yellow anthers (subtended by scales) spirally arranged upon a central axis; the pistillate oblong-cylindrical, 1 inch long, composed of orbicular, purple scales (subtended by yellow-green bracts) spirally arranged upon a central axis.

FRUIT.—Autumn of first season; oblong-cylindrical, erect, puberulous, dark purple cones, 2-4 inches long, about 1 inch thick; seeds ¼ inch long, shorter than their light brown wings.

WINTER-BUDS.—Globose, orange-green, resinous, ⅛-¼ inch in diameter.

BARK.—Twigs at first grayish and pubescent, becoming gray-brown and smooth; thin and smooth on young trunks, pale gray-brown and marked by swollen resin chambers; red-brown on old trunks and somewhat roughened by small, scaly plates.

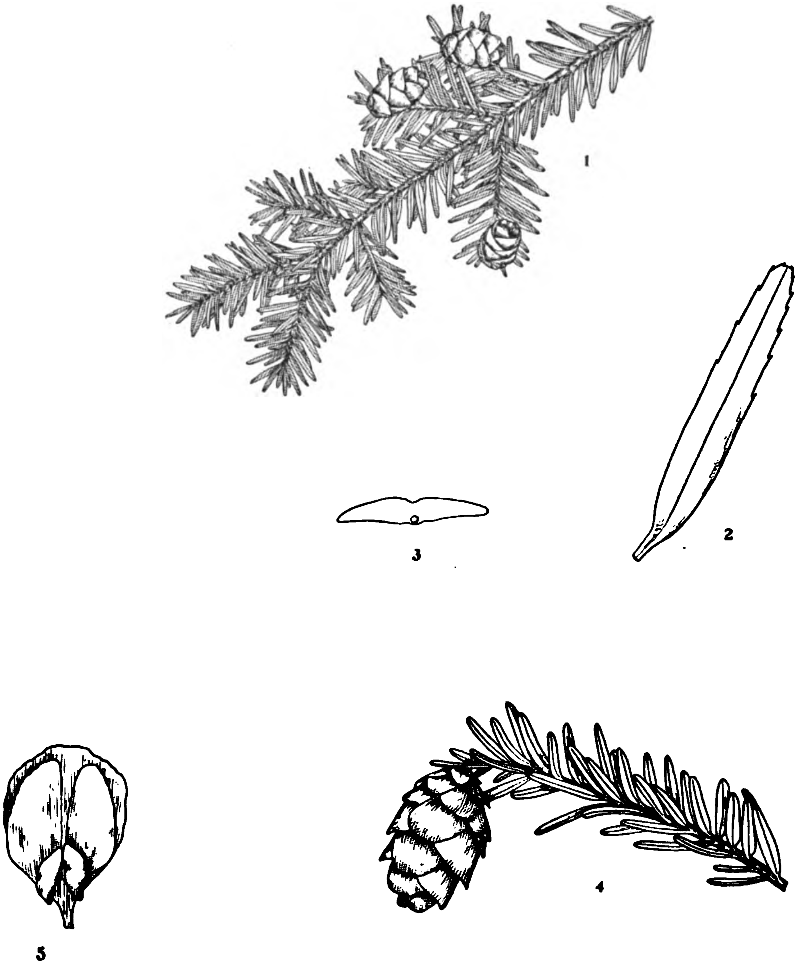
WOOD.—Very light, soft, weak, coarse-grained, perishable, pale brown, with thick, lighter colored sapwood. Page 221.

DISTRIBUTION.—Common in the mountain forests throughout Vermont, ascending to the summits of Mt. Mansfield and Camel's Hump, although there it is reduced to a low, scrubby growth; not reported in the Connecticut valley south of Hartland.

HABITAT.—Cold, wet woods and swamps, in the higher altitudes.

NOTES.—The balsam fir, more familiarly known as the fir tree or balsam, is a slender, graceful tree when growing in open ground. It bears a general resemblance to the spruces, but is distinguished easily from them on close observation. The leaves are flat, gray on the under side, with a conspicuous green midrib. The erect cones, 2 to 4 inches long, stand like Christmas candles on the upper branches. There is a characteristic fragrance from the bruised leaves and they are much prized for making pillows.

Hemlock



(Mich. Trees).

1. Fruiting branch viewed from beneath, x ½.
2. Leaf, x 3.
3. Cross-section of leaf, enlarged.
4. Branchlet with partly opened cone, x 1.
5. Cone-scale with seeds, x 3.

PINACEAE

Hemlock

Tsuga canadensis (L.) Carr.

HABIT.—A large tree 60-80 feet high, with a trunk 2-4 feet in diameter; forming a rather broad, open, somewhat irregular-pyramidal crown of slender, horizontal branches.

LEAVES.—Spirally arranged around the branch, but appearing 2-ranked by the twisting of their petioles; linear, flat, rounded at the apex; about ½ inch long; dark yellow-green and shining above, hoary beneath; short-petioled. Persistent about 3 years.

FLOWERS.—May; monoecious; the staminate axillary, short-stalked, light yellow, about ⅜ inch long, composed of subglobose clusters of stamens; the pistillate terminal, oblong, pale green, ⅛ inch long, the scales short, pinkish.

FRUIT.—Autumn of first season, gradually losing their seeds during the winter and falling the next spring; oblong-ovoid, acute, short-stalked, red-brown cones, about ¾ inch long; seeds ⅛ inch long, with wings about twice as long.

WINTER-BUDS.—Ovoid, obtuse, red-brown, slightly puberulous, ¹⁄₁₆ inch long.

BARK.—Twigs at first pale brown and pubescent, becoming glabrous, gray-brown; thick, red-brown or gray on the trunk, deeply divided into narrow, rounded, scaly ridges. Plate II.

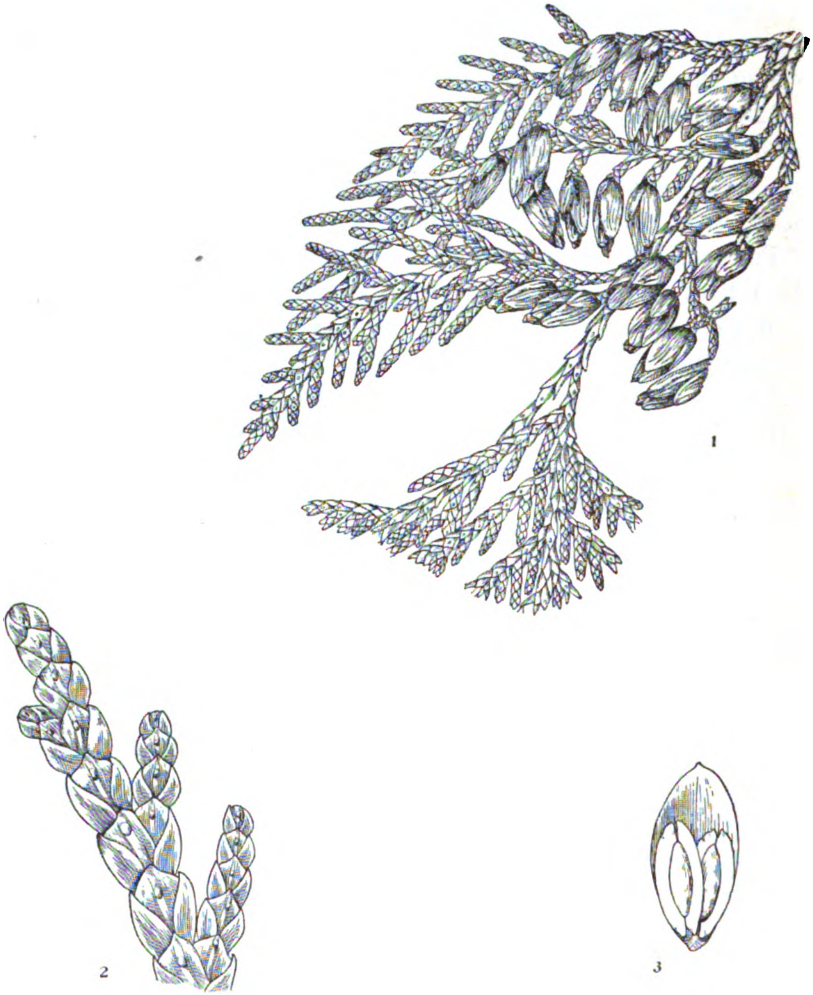
WOOD.—Light, soft, weak, brittle, coarse, and crooked-grained, not durable, ill-smelling, light red-brown, with thin, darker colored sapwood. Page 219.

DISTRIBUTION.—Common throughout Vermont, especially in the mountain forests.

HABITAT.—Rocky woods and hillsides; borders of swamps; mountain forests; low river-banks.

NOTES.—The hemlock is one of the most graceful of our evergreen trees. It may be met with almost everywhere from the low river-banks and swamps to the rocky hillsides and mountain forests. In distinguishing the hemlock from the spruce and balsam fir, one should notice the flat, petioled leaves arranged in a flattened spray with a row on the upper side lying close to the stem. The small ellipsoidal cones, scarcely more than three-fourths of an inch long, mature in the autumn and shed their seeds during the winter.

Arbor Vitae. White Cedar



(Mich. Trees).

1. **Fruiting branchlet, x 1.**
2. **Tip of branchlet, enlarged.**
3. **Cone-scale with seeds, x 3.**

PINACEAE

Arbor Vitae. White Cedar

Thuja occidentalis L.

HABIT.—A tree 40-50 feet high, with a short, often buttressed trunk 1-2 feet in diameter, often divided into 2-3 secondary stems; forming a rather dense, wide-based, pyramidal crown.

LEAVES.—Opposite, 4-ranked, scale-like, appressed; ovate, obtuse or pointed, keeled in the side pairs, flat in the others; ⅛-¼ inch long; yellow-green, often becoming brown in winter; strongly aromatic when crushed. Persistent 1-2 years.

FLOWERS.—April-May; usually monoecious; the staminate minute, globose, yellow, composed of 4-6 stamens arranged oppositely on a short axis; the pistillate small, oblong, reddish, composed of 8-12 scales arranged oppositely on a short axis.

FRUIT.—Early autumn of first season, but persistent on the branch through the winter; erect, short-stalked, oblong-ovoid, pale brown cones, about ½ inch long, composed of 8-12 loose scales; seeds ⅛ inch long, ovate, acute, winged.

WINTER-BUDS.—Naked, minute.

BARK.—Twigs, yellow-green, becoming light red, finally smooth, lustrous, dark orange-brown; thin, light red-brown on the trunk, slightly furrowed or deciduous in ragged strips.

WOOD.—Light, soft, brittle, rather coarse-grained, durable, fragrant, pale yellow-brown, with thin, whitish sapwood. Page 221.

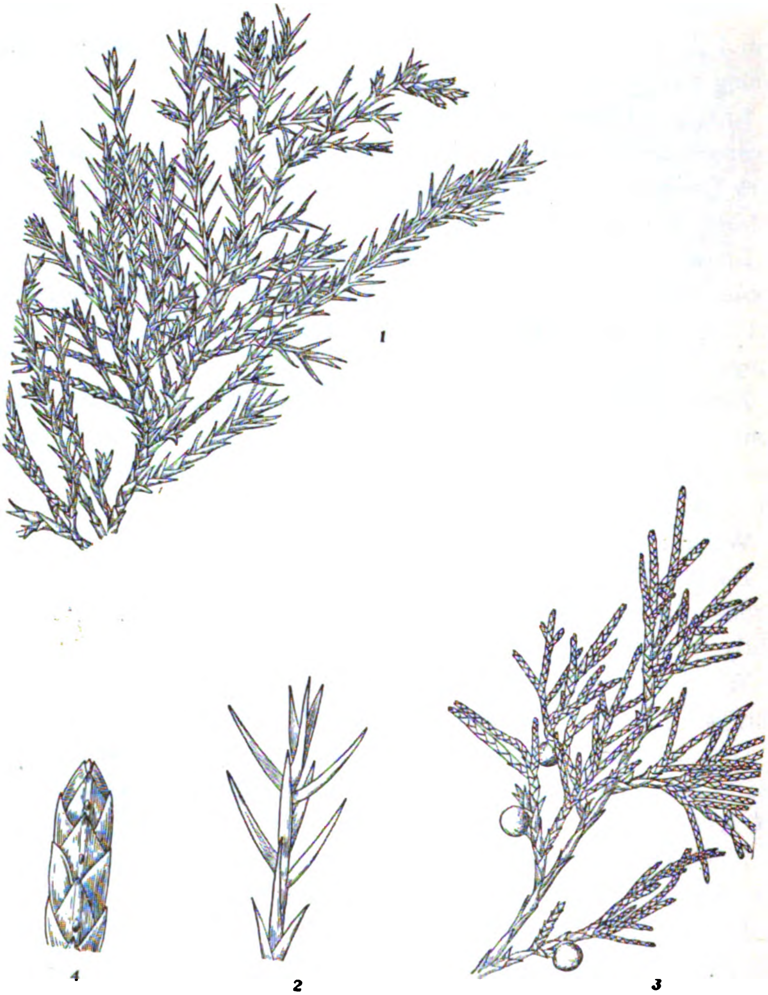
DISTRIBUTION.—Common in northern and central Vermont, and as far south as Woodstock and Hartland in eastern Vermont, up to 1,000 feet altitude.

HABITAT.—Swamps and along river-banks; rocky slopes; cool, moist hillsides.

NOTES.—This tree is known popularly in Vermont as the white cedar and is recognized easily by its striking pyramidal habit of growth and, upon closer examination, by its small scale-like leaves, in four rows but so flattened on the branchlets as to form fan-like sprays.

The straight slender trunks of this species are of especial value for posts and telegraph poles. Few timbers better withstand decay in the soil, fence posts sometimes lasting thirty or forty years. It is planted commonly for hedges and other ornamental purposes.

Red Cedar



(Mich. Trees).

1. **Branchlet with awl-shaped leaves, x 1.**
2. **Tip of branchlet, showing awl-shaped leaves, enlarged.**
3. **Fruiting branchlet with scale-like leaves, x 1.**
4. **Tip of branchlet, showing scale-like leaves, enlarged.**

PINACEAE

Red Cedar

Juniperus virginiana L.

HABIT.—A medium-sized tree 30-40 feet high, with a trunk diameter of a foot; forming an irregular, pyramidal or rounded crown.

LEAVES.—Opposite, of two kinds: (1) sessile, scale-like, closely appressed, overlapping, 4-ranked, ovate, acute, 1/16 inch long, (2) sessile, awl-shaped, loosely-arranged, 1/4-1/2 inch long. Persistent 5-6 years.

FLOWERS.—May; usually dioecious; minute; the staminate oblong-ovoid, composed of 4-6 shield-like scales, each bearing 4-5 yellow, globose pollen sacs; the pistillate ovoid, composed of about 3 pairs of fleshy, bluish scales, united at the base and bearing 2 ovules.

FRUIT.—Autumn of first or second season; subglobose, berry-like strobile, about 1/4 inch in diameter, dark blue and glaucous; flesh sweet and resinous; seeds 2-3.

WINTER-BUDS.—Naked, minute.

BARK.—Twigs greenish to red-brown and smooth; thin, light red-brown on the trunk, exfoliating lengthwise into long, narrow, persistent strips, exposing the smooth, brown inner bark.

WOOD.—Light, soft, close-grained, brittle, weak, durable, very fragrant, dull red, with thin, whitish sapwood.

DISTRIBUTION.—Common in lower altitudes of western Vermont, less so in the mountain range of southwestern Vermont; more or less common in the Connecticut valley as far north as Fairlee.

HABITAT.—Dry, rocky hills; also borders of lakes and streams, peaty swamps.

NOTES.—Three kinds of juniper are found in Vermont, but this one, commonly known as "red cedar," is the only one which has the size and habit of a tree. It somewhat resembles the arbor vitæ, from which it may be distinguished at a distance by its less symmetrical form and darker foliage. Closer inspection shows that its scale-like leaves have little tendency to the arrangement in a plane which is characteristic of the arbor vitæ. The fruit also is distinguishable readily from that of the other cone-bearing trees. It consists of thick, fleshy scales which coalesce to form a structure looking more like a small berry than a cone, green in midsummer, becoming bluish at maturity in the autumn. The leaves of young shoots are longer than those on the older branches, with needle-like points. The heartwood of this tree is soft, red and fragrant, and that obtained from the southern states is largely used in the manufacture of pencils.

SALICACEAE—WILLOWS

The classification of the willows is a task for the specialist, even when leaves and both staminate and pistillate flowers are obtainable. For this reason the usual summer and winter keys have been omitted.

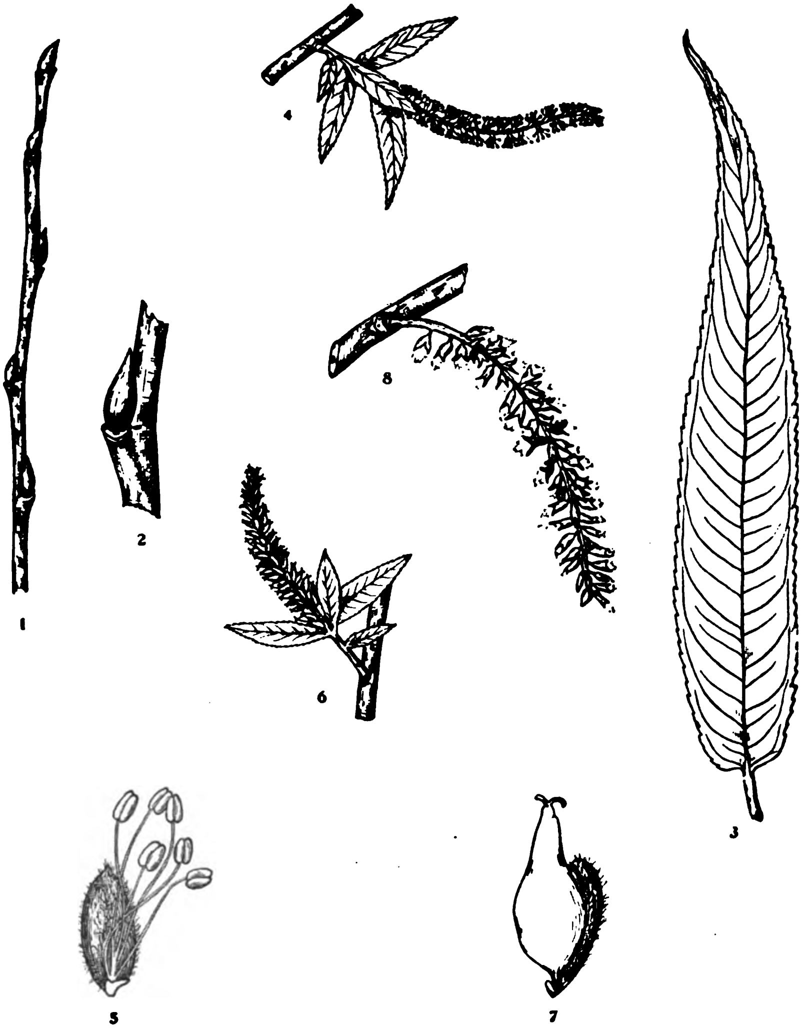
SALICACEAE

THE WILLOWS

The genus *Salix* is represented in Vermont by 25 distinct species or varieties and by a number of hybrids. The majority of these are shrubs, only a few becoming truly arborescent. Because of the similarity of their botanical characters, the frequency with which they hybridize, and the facility with which they respond to their environment, only an expert is competent to identify the species so abundant along our water courses and on the banks of our lakes and swamps. The scope of this work necessarily being limited, it has been deemed best to describe but one of our native willows and one of our foreign neighbors which is planted frequently.

Willows are introduced commonly as shade trees because they are propagated so easily by cuttings. Care should be taken, however, to select the stamen-bearing trees, both because these are more ornamental when in flower and because they do not produce the downy fruit which often is disagreeable when willows are growing near houses.

Black Willow



(Mich. Trees).

1. Winter twig, x 1.
2. Portion of twig, enlarged.
3. Leaf, x 1.
4. Staminate flowering branchlet, x 1.
5. Staminate flower, enlarged.
6. Pistillate flowering branchlets, x 1.
7. Pistillate flower, enlarged.
8. Fruiting branchlet, x 1.

SALICACEAE

Black Willow

Salix nigra Marsh.

HABIT.—A tree 30-50 feet high, with a short trunk, 1-2 feet in diameter; stout, spreading branches form a broad, rather irregular, open crown. Often a shrub.

LEAVES.—Alternate, simple, 3-6 inches long, ¼-¾ inch broad; lanceolate, very long-pointed, often curved at the tip; finely serrate; thin; bright green and rather lustrous above, paler and often hairy beneath; petioles very short, more or less pubescent.

FLOWERS.—May, with the leaves; dioecious; borne in crowded, slender, hairy catkins, 1-3 inches long; calyx 0; corolla 0; scales yellow, villous, with 3-6 stamens; ovary ovoid-conical, short-stalked, with stigmas nearly sessile.

FRUIT.—June; ovoid-conical capsule, ⅛ inch long, containing many minute seeds which are furnished with long, silky, white hairs.

WINTER-BUDS.—Terminal bud absent; lateral buds narrow-conical, acute, lustrous, red-brown, ⅛ inch long.

BARK.—Twigs glabrous or pubescent, bright red-brown, becoming darker with age; thick, dark brown or nearly black on old trunks, deeply divided into broad, flat ridges, often becoming shaggy.

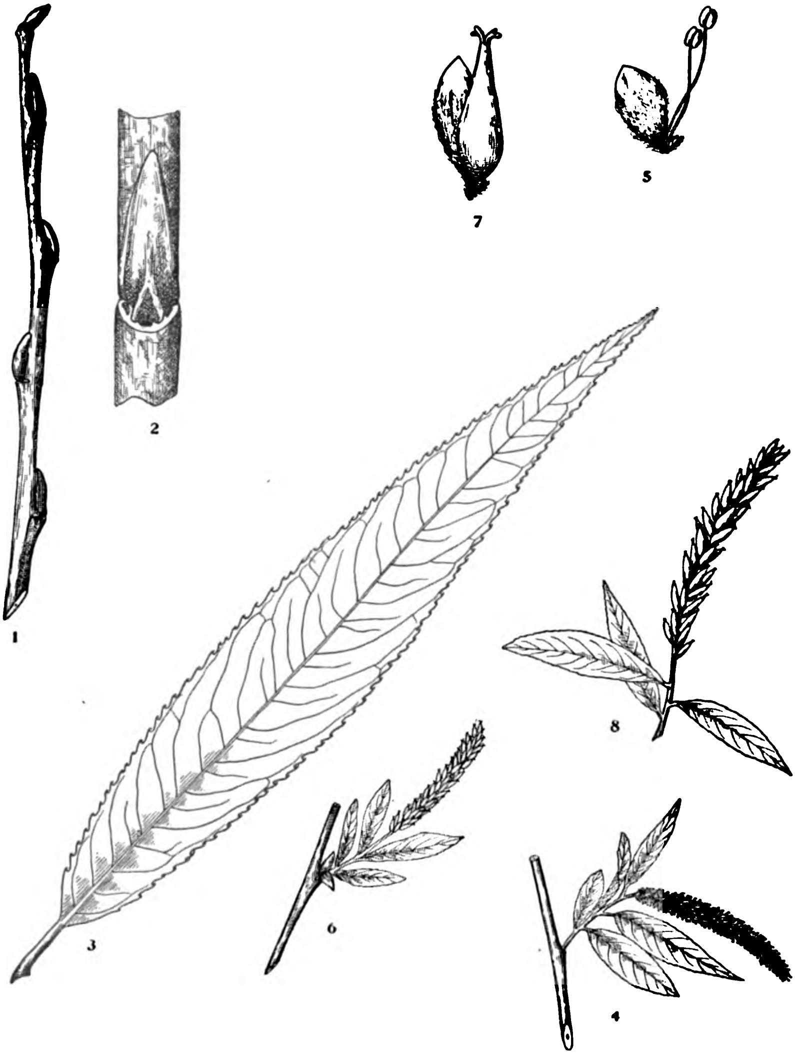
WOOD.—Light, soft, weak, close-grained, light red-brown, with thin, whitish sapwood.

DISTRIBUTION.—Common throughout Vermont.

HABITAT.—Banks of streams and ponds; lake-shores.

NOTES.—The black willow is a slender, rather graceful tree, common everywhere along the banks of lakes and streams. It may be recognized usually by its stouter dark brown or black twigs in contrast with the more slender, yellowish or bluish-green twigs of the European species. When the pendulous catkins open, three to five or more stamens may be found in each tiny flower. The leaves are green when mature and smooth except on the mid veins and petioles. The branchlets are very brittle at the base, and these, broken off by the wind, are carried down stream, often catching in the muddy banks and there taking root.

Crack Willow



(Mich. Trees).

1. Winter twig, x 1.
2. Portion of twig, enlarged.
3. Leaf, x 1.
4. Staminate flowering branchlet, x ½.
5. Staminate flower, enlarged.
6. Pistillate flowering branchlet, x ½.
7. Pistillate flower, enlarged.
8. Fruiting branchlet, x ½.

SALICACEAE

Crack Willow

Salix fragilis L.

HABIT.—A tree 50-60 feet high, with a short, stout trunk 3-4 feet in diameter; stout, spreading branches form a broad, open crown.

LEAVES.—Alternate, simple, 3-6 inches long, ½-1½ inches broad; lanceolate, long-pointed; finely glandular-serrate; thin and firm; lustrous, dark green above, paler beneath, glabrous both sides; petioles short, stout, with 2 glands at the junction of blade and petiole.

FLOWERS.—May, with the leaves; dioecious; borne in slender, pubescent catkins 1-3 inches long; calyx 0; corolla 0; scales blunt, somewhat pubescent; stamens usually 2; ovary abortive, with stigmas nearly sessile. Staminate trees rare.

FRUIT.—May-June; 1-celled, long-conical, short-stalked capsule, about ¼ inch long, containing many minute seeds which are furnished with long, silky, white hairs.

WINTER-BUDS.—Terminal bud absent; lateral buds long-conical, pointed, glabrous, bright red-brown, about ¼ inch long.

BARK.—Twigs pubescent, yellow-green, often reddish, becoming glabrous, lustrous, brown; thick, gray on the trunk, smooth in young trees, very rough, irregularly scaly-ridged in old trees.

WOOD.—Light, soft, tough, close-grained, red-brown, with thick, whitish sapwood.

NOTES.—This willow is a native of Europe and Asia, where it is a valuable timber tree. It is commonly cultivated and frequently escapes. The crack willow is hardy throughout Vermont, of very rapid growth, and thrives in rich, damp soil. The twigs are very brittle at the base and are broken easily by the wind, hence the name "crack willow."

THE POPLARS

The genus *Populus* belongs to the willow family and resemble the willows, especially in flower and fruit characters. The nodding, wormlike, staminate and pistillate catkins are borne upon different trees, and opening before the leaves, are conspicuous in early spring. The poplars are distributed quite widely, extending from the Arctic Circle to Mexico and from the Atlantic to the Pacific.

The wood of poplars is very soft and light and especially liable to warp, but is cheap and useful for making toys, boxes and smaller furniture. Much of it now goes to the pulp mills.

SUMMER KEY TO THE SPECIES OF POPULUS

a. Leaf-petioles essentially terete.
  b. Petioles and lower sides of leaves pubescent; leaves heart-shaped .... **P. candicans,** p. 71.
  bb. Petioles and lower sides of leaves glabrous; leaves ovate-lanceolate .... **P. balsamifera,** p. 69.
aa. Leaf-petioles strongly flattened.
  b. Petioles and lower sides of leaves tomentose; twigs pubescent, **P. alba,** p. 63.
  bb. Petioles and lower sides of leaves glabrous; twigs glabrous.
    c. Leaves distinctly deltoid in shape.
      d. Leaves broader than they are long, abruptly acuminate at the apex; marginal teeth not conspicuously incurved; branches erect and more or less appressed to the main stem, forming a narrow, spire-like crown. **P. nigra italica,** p. 75.
      dd. Leaves longer than they are broad, more or less taper-pointed at the apex; marginal teeth rather conspicuously incurved; branches spreading, forming a broad crown. **P. deltoides,** p. 73.
    cc. Leaves ovate to nearly orbicular in shape.
      d. Margin of leaves coarsely sinuate-toothed; leaves 3-5 inches long .... **P. grandidentata,** p. 67.
      dd. Margin of leaves finely serrate; leaves less than 3 inches long .... **P. tremuloides,** p. 65.

WINTER KEY TO THE SPECIES OF POPULUS

a. Branches erect, more or less appressed to the main stem, forming a narrow, spire-like crown..............**P. nigra italica,** p. 75.

aa. Branches spreading, forming a broad crown.

  b. Terminal buds ⅛-¼ inch long, not resinous.

    c. Buds and twigs more or less conspicuously white-downy; twigs green ....**P. alba,** p. 63.

    cc. Buds and twigs not conspicuously white-downy; twigs usually red-brown.

      d. Terminal buds about ⅛ inch long, puberulous, dusty-looking; lateral buds widely divergent; twigs rather coarse ....**P. grandidentata,** p. 67.

      dd. Terminal buds about ¼ inch long, glabrous, lustrous; lateral buds more or less appressed; twigs rather slender, **P. tremuloides,** p. 65.

  bb. Terminal buds ½-1 inch long, sticky-resinous.

    c. Terminal buds about ½ inch long; buds not fragrant; twigs usually yellow, more or less strongly angled, **P. deltoides,** p. 73.

    cc. Terminal buds nearly 1 inch long; buds fragrant; twigs usually red-brown and seldom strongly angled,
P. balsamifera,[1] p. 69.
P. candicans,[1] p. 71.

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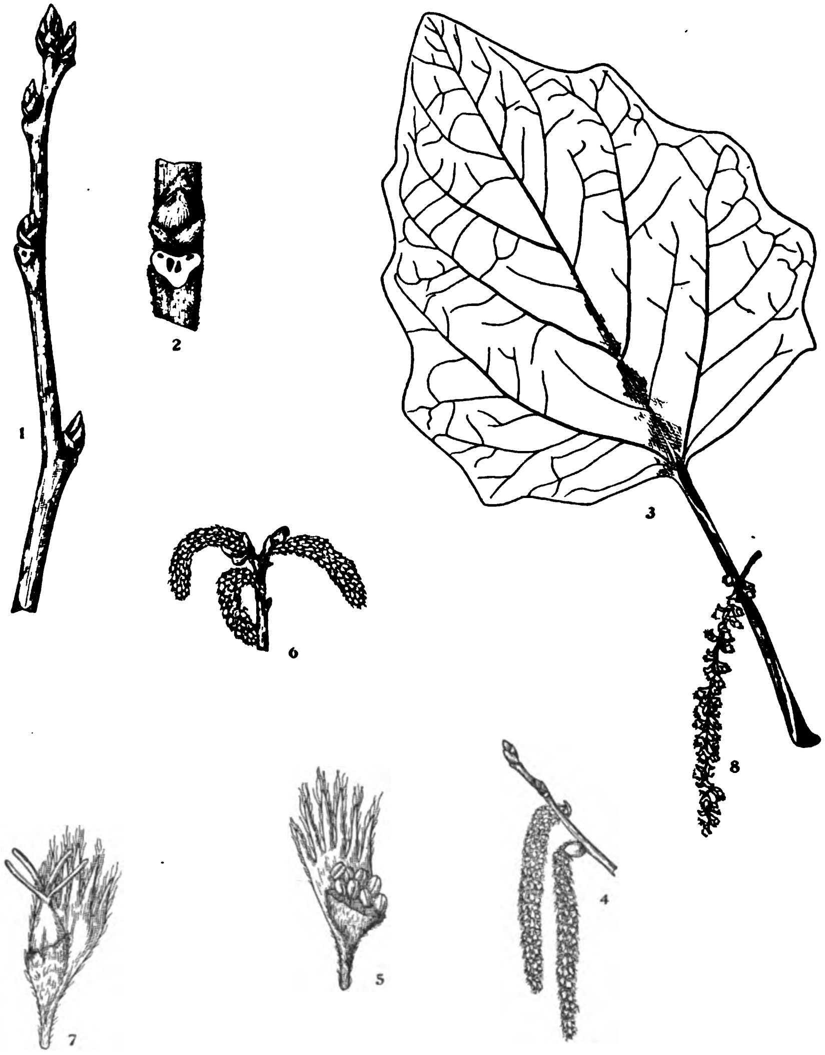
[1] It is difficult to distinguish between these species in the absence of summer characters. If leaves can be found on or beneath a tree which is sufficiently segregated from similar trees as to avoid any chance for error, the summer key on the opposite page may be used.

White Poplar. Silver-leaved Poplar



(Mich. Trees).

1. Winter twig, x 1.
2. Portion of twig, enlarged.
3. Leaf, x 2.
4. Staminate flowering branchlet, x ½.
5. Staminate flower, enlarged.
6. Pistillate flowering branchlet, x ½.
7. Pistillate flower, enlarged.
8. Fruit, x ½.

SALICACEAE

White Poplar. Silver-leaved Poplar

Populus alba L.

HABIT.—A large tree 50-75 feet high, with a trunk diameter of 2-4 feet, forming a large, spreading, rounded or irregular crown of large, crooked branches and sparse, stout branchlets.

LEAVES.—Alternate, simple, 2-4 inches long and almost as broad; broadly ovate to suborbicular; irregularly toothed, sinuate, or sometimes 3-5-lobed; glabrous, dark green above, white-tomentose to glabrous beneath; petioles long, slender, flattened, tomentose.

FLOWERS.—April-May, before the leaves; dioecious; the staminate catkins thick, cylindrical, 2-4 inches long; the pistillate catkins slender, 1-2 inches long; calyx 0; corolla 0; stamens 6-16, with purple anthers; stigmas 2, yellow.

FRUIT.—May-June; ovoid, 2-valved capsules, 1/8-1/4 inch long, borne in drooping catkins 2-4 inches long; seeds light brown, surrounded by long, white hairs.

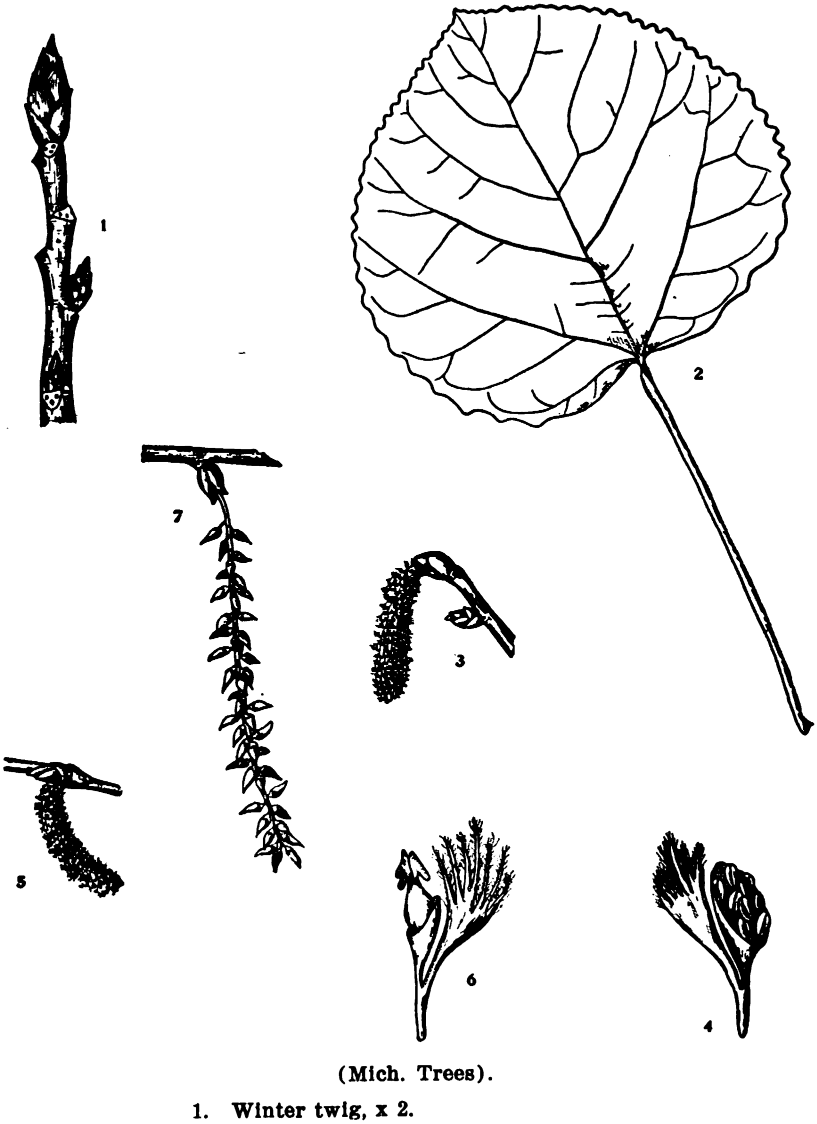
WINTER-BUDS.—Ovoid, pointed, not viscid, downy, about 1/4 inch long.

BARK.—Twigs greenish, covered with a white down, becoming greenish gray and marked with darker blotches; dark gray and fissured at the base of old trunks.

WOOD.—Light, soft, weak, difficult to split, reddish yellow, with thick, whitish sapwood.

NOTES.—The white poplar is a native of Europe and Asia. It is hardy in Vermont, and is cultivated frequently, occasionally becoming an escape. It grows rapidly in good soils but thrives also in poor soils and in exposed situations. The deep roots produce numerous suckers for a considerable distance from the tree.

American Aspen. Trembling Poplar. Popple



(Mich. Trees).

1. Winter twig, x 2.
2. Leaf, x 1.
3. Staminate flowering branchlet, x ½.
4. Staminate flower, enlarged.
5. Pistillate flowering branchlet, x ½.
6. Pistillate flower, enlarged.
7. Fruit, x ½.

SALICACEAE

American Aspen. Trembling Poplar. Popple

Populus tremuloides Michx.

HABIT.—A small, slender tree generally 35-45 feet high, with a trunk diameter of 8-15 inches; forming a loose, rounded crown of slender branches.

LEAVES.—Alternate, simple, 1½-2½ inches long and broad; broadly ovate to suborbicular; finely serrate; thin and firm; lustrous, dark green above, dull and pale beneath; petioles slender, laterally compressed. Tremulous with the slightest breeze.

FLOWERS.—April, before the leaves; dioecious; the staminate catkins 1½-3 inches long, the pistillate at first about the same length, gradually elongating; calyx 0; corolla 0; stamens 6-12; stigmas 2, 2-lobed, red.

FRUIT.—May-June; 2-valved, oblong-cylindrical, short-pedicelled capsules ¼ inch long; seeds light brown, white-hairy.

WINTER-BUDS.—Terminal bud about ¼ inch long, narrow-conical, acute, red-brown, lustrous; lateral buds often appressed.

BARK.—Twigs very lustrous, red-brown, becoming grayish and roughened by the elevated leaf-scars; thin, yellowish or greenish and smooth on the trunk, often roughened with darker, horizontal bands or wart-like excrescences, becoming thick and fissured, almost black at the base of old trunks.

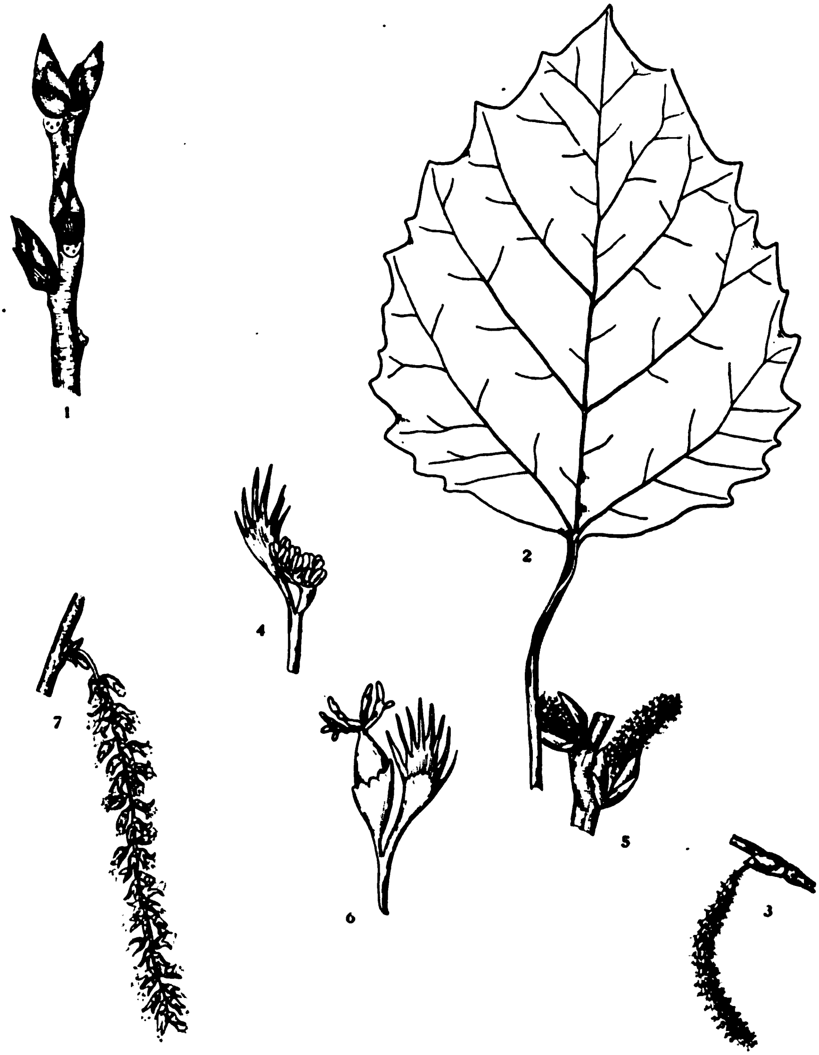
WOOD.—Light, soft, weak, close-grained, not durable, light brown, with thin, whitish sapwood. Page 229.

DISTRIBUTION.—Common throughout Vermont.

HABITAT.—Prefers moist, sandy soil and gravelly hillsides.

NOTES.—The most careless observer cannot have failed to notice the leaves of the aspen continually trembling on the quietest summer day. This tremulousness, indeed, has given name to the species. The reason for it, as may be seen readily by examination of any leaf, lies in the decidedly flattened structure of the leaf-stem or petiole. The slender drooping catkins appear in early spring and the downy fruits ripen in the latter part of May. The American aspen grows to a medium size, and is the most widely distributed tree in North America, extending from Labrador to Alaska, from Lower California to the Atlantic coast.

Large-toothed Aspen



(Mich. Trees).

1. Winter twig, x 2.
2. Leaf, x 1.
3. Staminate flowering branchlet, x ½.
4. Staminate flower, enlarged.
5. Pistillate flowering branchlet, x ½.
6. Pistillate flower, enlarged.
7. Fruit, x ½.

SALICACEAE

Large-toothed Aspen

Populus grandidentata Michx.

HABIT.—A medium-sized tree 30-50 feet high, with a slender trunk 12-20 inches in diameter; forming a loose, oval or rounded crown of slender, spreading branches and coarse spray.

LEAVES.—Alternate, simple, 3-5 inches long, two-thirds as broad; orbicular-ovate; coarsely and irregularly sinuate-toothed; thin and firm; dark green above, paler beneath, glabrous both sides; petioles long, slender, laterally compressed.

FLOWERS.—April-May, before the leaves; dioecious; the staminate in short-stalked catkins 1-3 inches long; the pistillate in loose-flowered, long-stalked catkins at first about the same length, but gradually elongating; calyx 0; corolla 0; stamens 6-12, with red anthers; stigmas 2, 2-lobed, red.

FRUIT.—May-June; 2-valved, conical, acute, hairy capsules ⅛ inch long, borne in drooping catkins 4-6 inches long; seeds minute, dark brown, hairy.

WINTER-BUDS.—Terminal bud ⅛ inch long, ovoid to conical, acute, light chestnut, puberulous, dusty-looking.

BARK.—Twigs greenish gray and at first hoary-tomentose, becoming lustrous, orange or red-brown and finally greenish gray; thick, dark red-brown or blackish at the base of old trunks, irregularly fissured, with broad, flat ridges.

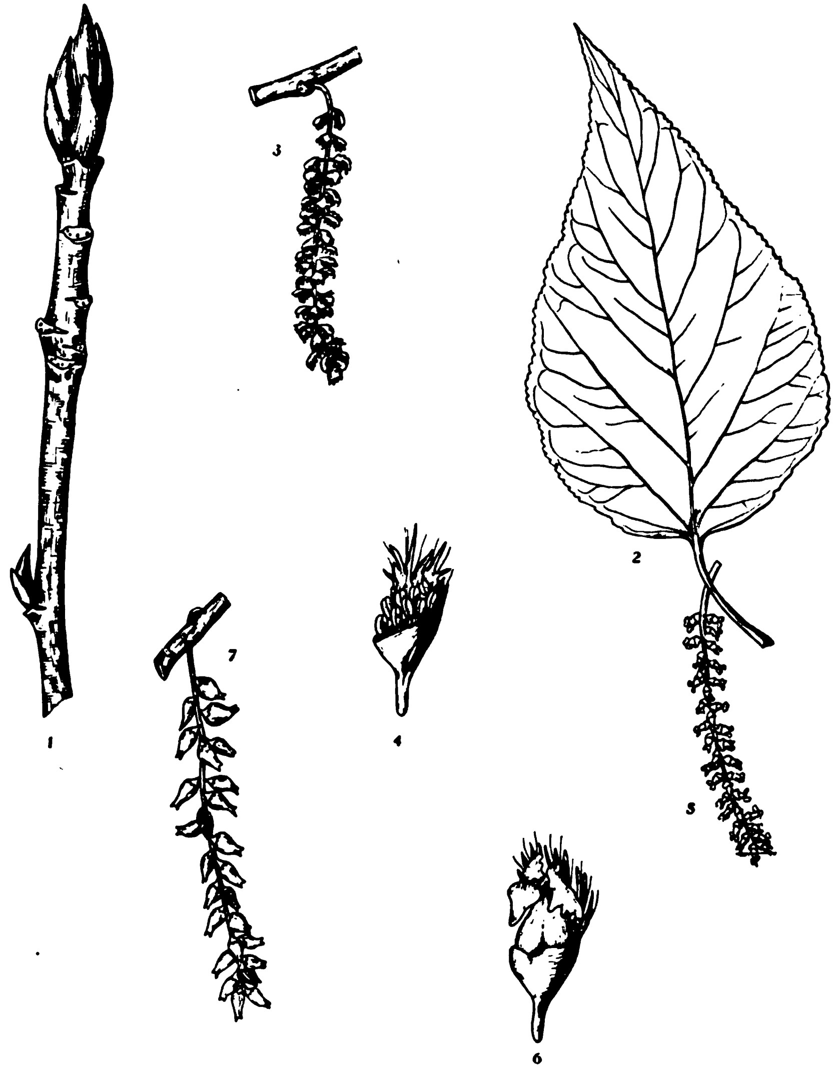
WOOD.—Light, soft, weak, close-grained, light brown, with thin, whitish sapwood.

DISTRIBUTION.—Frequent throughout Vermont.

HABITAT.—Prefers rich, moist, sandy soil; rich woods.

NOTES.—The name of this tree suggests an easy way of identifying it. The coarse-toothed margin of the leaf is a constant characteristic and may be relied upon. The pollen-bearing catkins are seen first, the ovule-bearing catkins appearing a little later on other trees. The fruits ripen when the leaves are unfolding. The young leaves are downy-white on both sides, but later become green and smooth.

Balsam Poplar. Tacamahac



(Mich. Trees).

1. Winter twig, x 1.
2. Leaf, x ¾.
3. Staminate flowering branchlet, x ½.
4. Staminate flower, enlarged.
5. Catkin of pistillate flower, x ½.
6. Pistillate flower, enlarged.
7. Fruit, x ½.

SALICACEAE

Balsam Poplar. Tacamahac

Populus balsamifera L.

HABIT.—A tree 50-75 feet high, with a trunk diameter of 1-3 feet; forming a rather narrow, open, pyramidal crown of few, slender, horizontal branches.

LEAVES.—Alternate, simple, 3-6 inches long, about one-half as broad; ovate to ovate-lanceolate; finely crenate-serrate; thin and firm; lustrous, dark green above, paler beneath; petioles 1½ inches long, slender, terete, smooth.

FLOWERS.—April-May, before the leaves; dioecious; the staminate in long-stalked catkins 3-4 inches long; the pistillate in loose-flowered, long-stalked catkins 4-5 inches long; calyx 0; corolla 0; stamens 20-30, with bright red anthers; ovary short-stalked; stigmas 2, wavy-margined.

FRUIT.—May-June; 2-valved, ovoid, short-pedicelled capsules ¼ inch long, borne in drooping catkins 4-6 inches long; seeds light brown, hairy.

WINTER-BUDS.—Terminal bud about 1 inch long, ovoid, long-pointed, brownish, resin-coated, sticky, fragrant.

BARK.—Twigs red-brown, becoming dark orange, finally green-gray; thick, grayish on old trunks, and shallowly fissured into broad, rounded ridges, often roughened by dark excrescences.

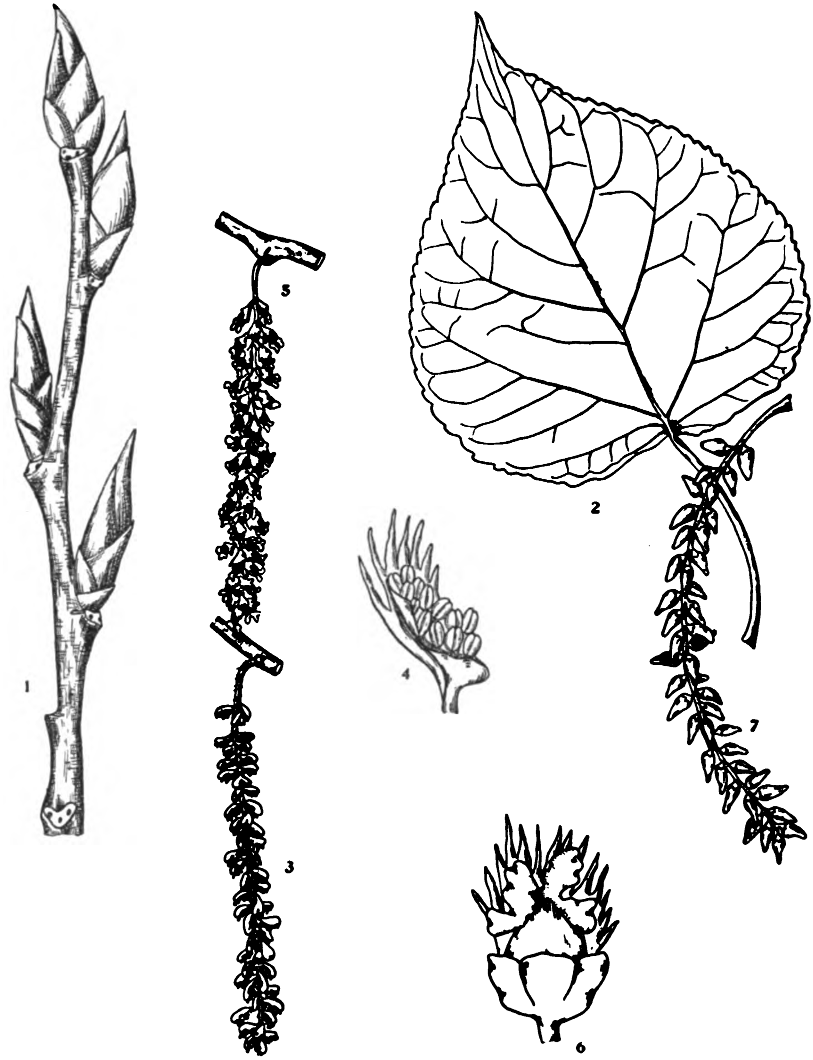
WOOD.—Light, soft, weak, close-grained, light red-brown, with thick, nearly white sapwood.

DISTRIBUTION.—Frequent throughout Vermont; often planted as a shade tree.

HABITAT.—Borders of streams and swamps; wet ravines.

NOTES.—This tree is a northern species ranging from northern New England to the Alaskan coast. It is subject to great variation in the form of the leaves. Some are almost triangular with a deeply heart-shape base, while others are very slender with a wedge-shape base. The buds and young leaves are covered with a gummy excretion which sometimes is soaked out and used in preparing ointments. It is often confused with *P. candicans*, p. 71.

Balm of Gilead



(Mich. Trees).

1. Winter twig, x 1.
2. Leaf, x ½.
3. Staminate flowering branchlet, x ½.
4. Staminate flower, enlarged.
5. Pistillate flowering branchlet, x ½.
6. Pistillate flower, enlarged.
7. Fruit, x ½.

SALICACEAE

Balm of Gilead

Populus candicans Ait. [Populus balsamifera candicans (Ait.) Gray]

HABIT.—A tree 50-70 feet high, with a trunk diameter of 1-3 feet; more spreading branches than in *P. balsamifera,* forming a broader and more open crown.

LEAVES.—Resemble those of *P. balsamifera,* but more broadly heart-shaped and more coarsely serrate; more or less pubescent when young; petioles pubescent.

FLOWERS.—Similar to those of *P. balsamifera.*

FRUIT.—Similar to that of *P. balsamifera.*

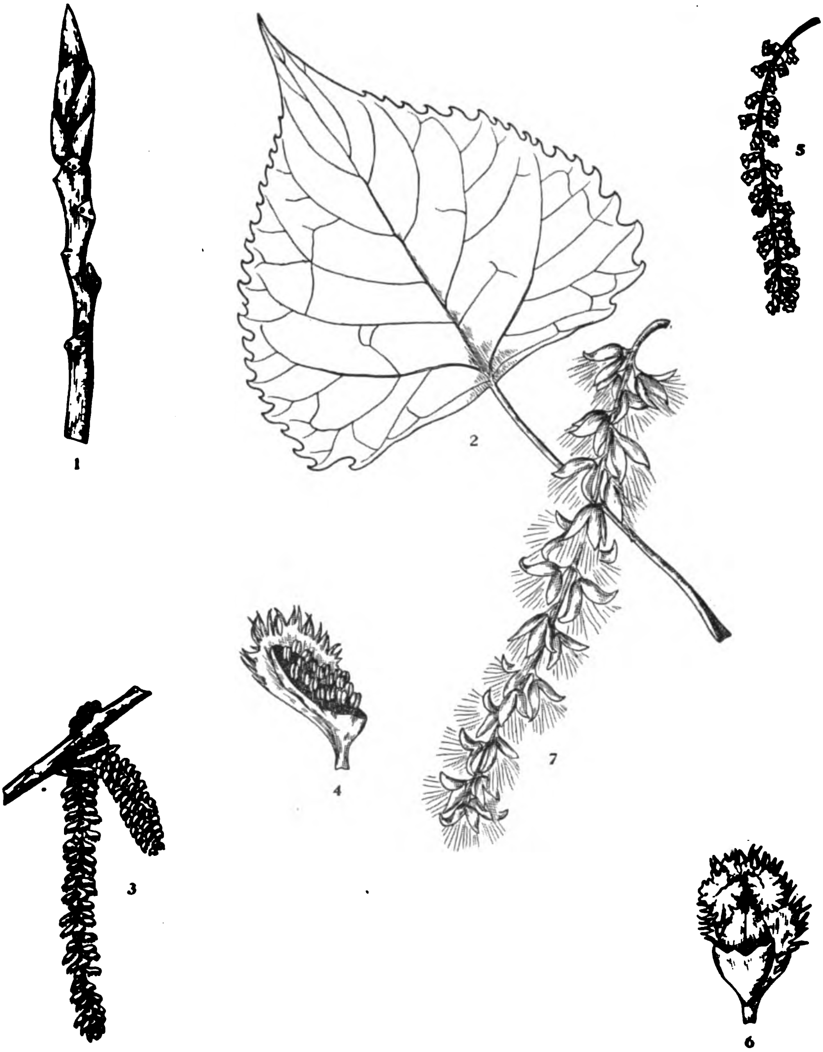
WINTER-BUDS.—Terminal bud about 1 inch long, ovoid, long-pointed, dark red-brown, resinous throughout, viscid, very aromatic.

BARK.—Twigs reddish or olive-green, with occasional longitudinal gray lines, covered with a fragrant, gummy secretion, becoming gray-green; dark gray, rough, irregularly striate and firm on old trunks.

WOOD.—Resembles that of *P. balsamifera,* but is somewhat heavier.

NOTES.—The Balm of Gilead occasionally is cultivated and sometimes escapes to the roadsides. It was long confused with *P. balsamifera.* Further investigation may show it to be a native along our northern border. It grows rapidly in all soils and situations and spreads rapidly by suckers from the roots.

Cottonwood. Necklace Poplar



(Mich. Trees).

1. Winter twig, x 1.
2. Leaf, x ½.
3. Staminate flowering branchlet, x ½.
4. Staminate flower, enlarged.
5. Pistillate catkin, x ½.
6. Pistillate flower, enlarged.
7. Fruit, x ½.

SALICACEAE

Cottonwood. Necklace Poplar

Populus deltoides Marsh. [Populus monilifera Ait.]

HABIT.—A stately tree attaining a height of 70-90 feet and a trunk diameter of 3-5 feet; forming a spreading, open, symmetrical crown of massive, horizontal branches and stout, more or less angled branchlets.

LEAVES.—Alternate, simple, 3-6 inches long, nearly as broad; broadly deltoid-ovate; coarsely crenate-serrate above the entire base; thick and firm; lustrous, dark green above, paler beneath; petioles 2-3 inches long, slender, compressed laterally.

FLOWERS.—April-May, before the leaves; dioecious; the staminate in short-stalked, densely-flowered catkins 3-4 inches long; the pistillate in short-stalked, few-flowered catkins elongating to 6-8 inches; calyx 0; corolla 0; stamens very numerous, with red anthers; stigmas 3-4, spreading.

FRUIT.—May; 2-4-valved, short-stalked capsules, borne in drooping catkins 5-10 inches long; seeds light brown, densely cottony.

WINTER-BUDS.—Terminal bud ½ inch long, conical, acute, very resinous, shining, brownish.

BARK.—Twigs and young stems smooth, yellow-green; old trunks ashy gray, deeply divided into straight furrows with broad, rounded ridges.

WOOD.—Light, soft, weak, close-grained, dark brown, with thick, whitish sapwood; warps badly and is difficult to season.

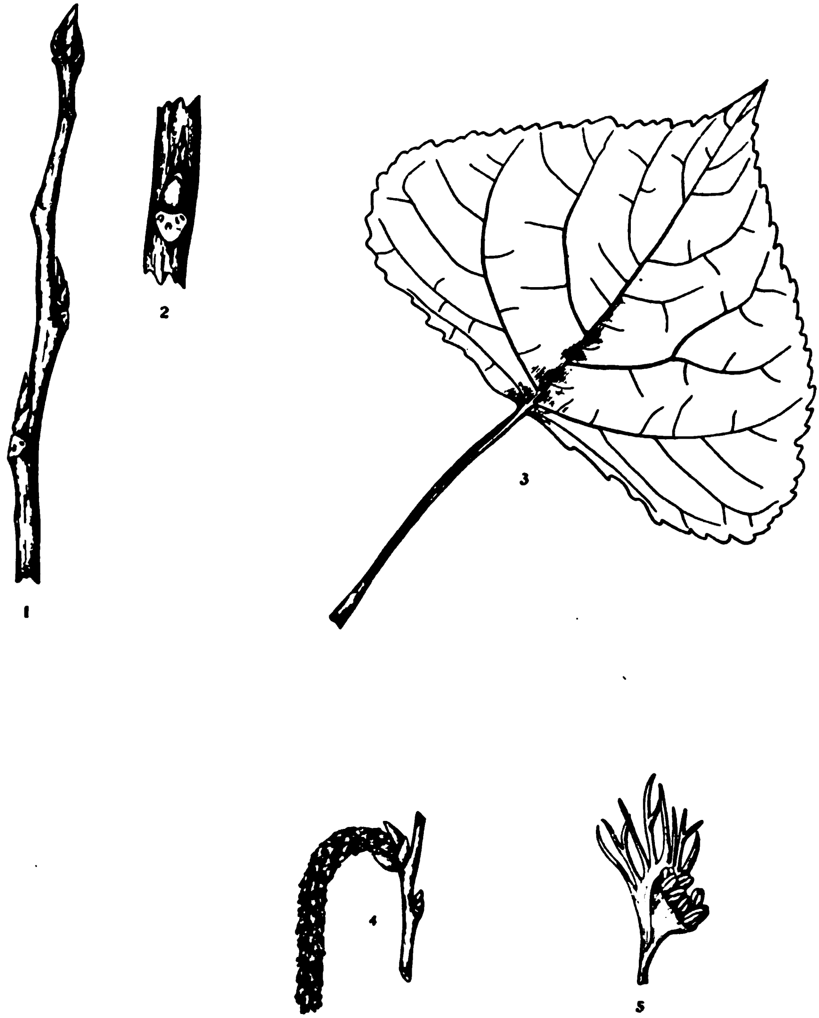
DISTRIBUTION.—Frequent in western Vermont.

HABITAT.—Prefers rich, moist soil, such as river-banks, river-bottoms or lake-shores; grows well in drier situations.

NOTES.—The cottonwood occurs native in the Champlain valley and along its tributary streams, and south in western Vermont to the Hoosic valley in Pownal, where it is particularly abundant. It occurs along the Connecticut river in southeastern Vermont at least as far north as Brattleboro. It has been planted as a shade tree in other localities usually under the name of "Carolina poplar." The stamen-bearing trees always should be chosen for this purpose since the abundant, cottony seed is a nuisance near dwellings.

The cottonwood is the most massive of our deciduous trees, sometimes reaching 100 feet in height and five to seven feet in diameter. Such isolated giants have become the familiar landmarks of many roadsides near Lake Champlain. It is a rapid-growing tree but short-lived and poorly adapted to street planting.

Lombardy Poplar



(Mich. Trees).

1. **Winter twig, x 1.**
2. **Portion of twig, enlarged.**
3. **Leaf, x ¾.**
4. **Staminate flowering branchlet, x ½.**
5. **Staminate flower, enlarged.**

SALICACEAE

Lombardy Poplar

Populus nigra italica DuRoi [Populus fastigiata Desf.] [Populus dilatata Ait.]

HABIT.—A tree 75-100 feet high, with a short, ridged and buttressed trunk 4-6 feet in diameter and a narrow, spire-like crown of erect branches.

LEAVES.—Alternate, simple, 2-4 inches long, and usually somewhat broader than long; broad-deltoid, abruptly acuminate at the apex; finely but bluntly crenate-serrate; thick and firm; dark green and shining above, lighter and more or less lustrous beneath; petioles slender, laterally compressed, 1-2 inches long.

FLOWERS.—April-May, before the leaves; dioecious; the staminate in sessile, dark red, cylindrical catkins about 3 inches long; the pistillate not present in the United States; calyx 0; corolla 0; stamens about 8, with white filaments and purple anthers.

FRUIT.—Not formed in the United States in the absence of pistillate flowers.

WINTER-BUDS.—Terminal bud conical, slightly angled, taper-pointed, glutinous, about 3/8 inch long; lateral buds smaller, appressed.

BARK.—Twigs glabrous, shining yellow, becoming gray; thick and gray-brown on old trunks, deeply and irregularly furrowed.

WOOD.—Light, soft, easily worked, not liable to splinter, weak, not durable, light red-brown, with thick, nearly white sapwood.

NOTES.—This tree is thought to be a native of Afghanistan. It is frequently cultivated in Vermont and tends to spread by sprouting from the roots. It is used for ornamental purposes on account of its very rapid growth; but it is short-lived, its limbs die early, and these remain, causing the tree to become unsightly in a very few years.

THE WALNUTS

Every school boy in Vermont has some acquaintance at least with the butternut and its sweet, tender nuts. It occurs along the hillsides and river-valleys throughout the State. The staminate flowers appear in May and hang in graceful, slender catkins five or six inches long. These are generally found on the second-year shoots, while the pistillate flowers are borne on the terminal shoots. Butternut trees show some irregularities, however, in reference to the time and order of the appearance of the two kinds of flowers so that the pollen-bearing clusters may mature either some ten days earlier or later than the ovule-bearing ones on the same tree. This may be the cause of the variability often noticed in the crop of butternuts. The peculiarity offers an interesting subject for further observation.

The meat of the butternut needs no recommendation, but the excellencies of pickles made from the young mucilaginous nuts are not so well known. For this purpose they should be gathered early in June and the clammy pubescence removed by plunging them into boiling water and rubbing with a coarse cloth.

The other member of this family, the black walnut, is not known so well in Vermont. It is not a native tree in Vermont, although it occurs occasionally in Southern New England, becoming more abundant southward and westward. It is planted often for ornamental uses and is a much better tree for this purpose than our native walnut.

SUMMER KEY TO THE SPECIES OF JUGLANS

a. Leaflets 11-17, the terminal usually present; pith of twigs chocolate-brown; bark of trunk rather smooth, or fissured, with broad, flat, whitish ridges; fruit elongated, sticky-downy. . **J. cinerea,** p. 79.

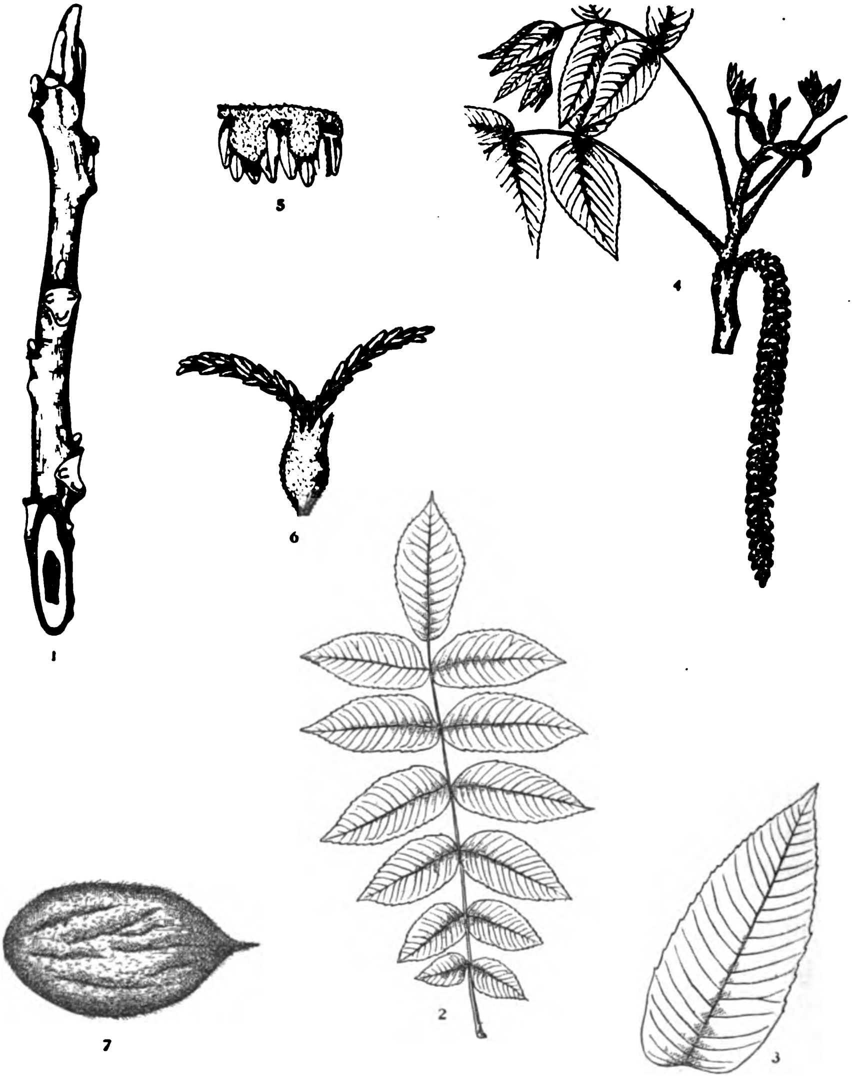
aa. Leaflets 13-23, the terminal often lacking; pith of twigs cream colored; bark of trunk rough, brownish or blackish, deeply furrowed by broad, rounded ridges; fruit globose, not sticky-downy,
J. nigra, p. 81.

WINTER KEY TO THE SPECIES OF JUGLANS

a. Pith chocolate-brown; leaf-scar with downy pad above; fruit elongated, sticky-downy; terminal bud ½-¾ inch long; bark rather smooth, or fissured, with broad, flat, whitish ridges,
J. cinerea, p. 79.

aa. Pith cream colored; leaf-scar without downy pad above; fruit globose, not sticky-downy; terminal bud ⅓ inch long; bark rough, brownish or blackish, deeply furrowed by broad, rounded ridges,
J. nigra, p. 81.

Butternut



(Mich. Trees).

1. Winter twig, x 1.
2. Leaf, x ⅙.
3. Leaflet, x ½.
4. Flowering branchlet, x ½.
5. Staminate flower, enlarged.
6. Pistillate flower, enlarged.
7. Fruit, x ½.

JUGLANDACEAE

Butternut

Juglans cinerea L.

HABIT.—A medium-sized tree 30-50 feet high, with a short trunk 2-3 feet in diameter; forming a wide-spreading crown of large, horizontal branches and stout, stiff branchlets.

LEAVES.—Alternate, compound, 15-30 inches long. Leaflets 11-17, 2-4 inches long and one-half as broad; sessile, except the terminal; oblong-lanceolate; finely serrate; thin; yellow-green and rugose above, pale and soft-pubescent beneath. Petioles stout, hairy.

FLOWERS.—May, with the leaves; monoecious; the staminate in cylindrical, greenish, drooping catkins 3-5 inches long; calyx 6-lobed, borne on a hairy bract; corolla 0; stamens 8-12, with brown anthers; the pistillate solitary or several on a common peduncle, about ⅓ inch long, their bracts and bractlets sticky-hairy; calyx 4-lobed, hairy; corolla 0; styles 2; stigmas 2, fringed, spreading, bright red.

FRUIT.—October; about 2½ inches long, cylindrical, pointed. greenish, sticky-downy, solitary or borne in drooping clusters of 3-5; nuts with rough shells, inclosing a sweet, but oily kernel; edible.

WINTER-BUDS.—Terminal bud ½-¾ inch long, oblong-conical, obliquely blunt, somewhat flattened, brownish, pubescent.

BARK.—Twigs orange-brown or bright green, rusty-pubescent, becoming smooth and light gray; gray and smoothish on young trunks, becoming brown on old trunks, narrow-ridged, with wide furrows. Plate II.

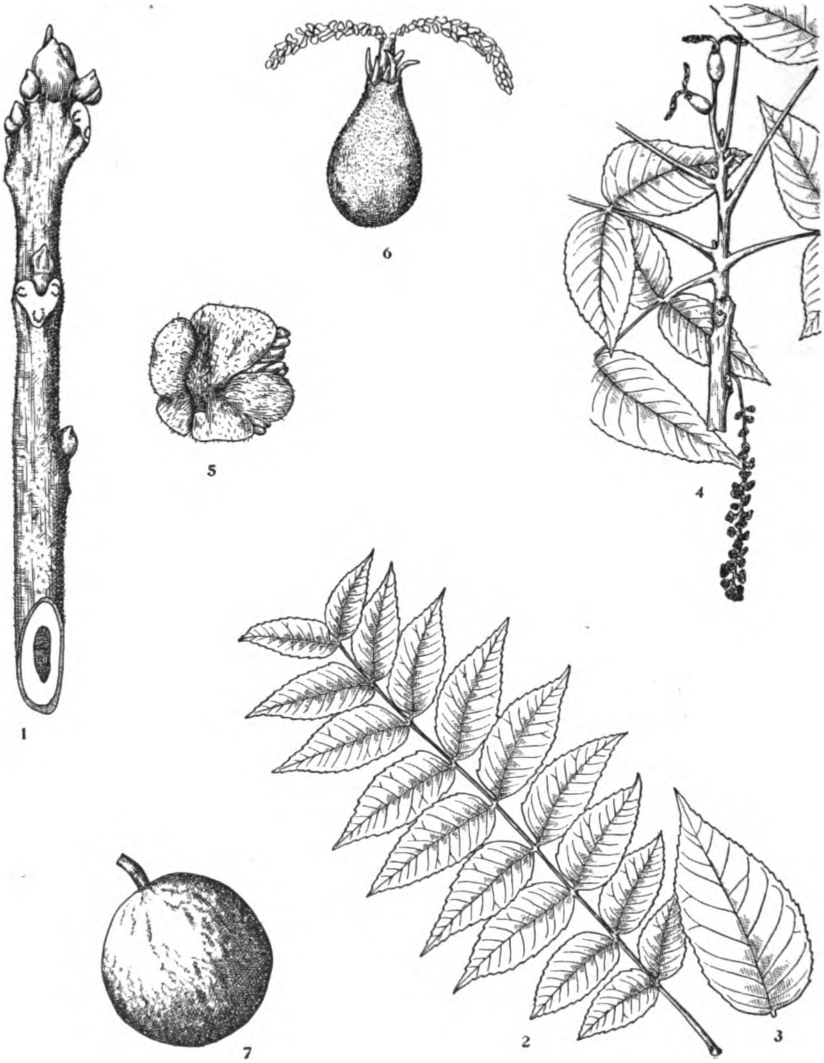
WOOD.—Light, soft, weak, coarse-grained, light brown, with thin, lighter colored sapwood.

DISTRIBUTION.—Of frequent occurrence throughout Vermont.

HABITAT.—Prefers low, rich woods; river-banks; low hillsides; rocky hillsides.

NOTES.—The leaves of the butternut appear late and fall early. The young trees are very attractive but the larger trees usually are scraggy and unsound. Some preliminary work done in Dorset, Bennington County, seems to indicate that perhaps through some peculiar root antagonism the butternut will kill the shrubby cinquefoil (*Potentilla fructicosa*), a shrub which is destroying some of the best pastures in Northwestern Connecticut, Berkshire County, Massachusetts and Bennington and Rutland Counties, Vermont.

Black Walnut



(Mich. Trees).

1. Winter twig, x 1.
2. Leaf, x ⅛.
3. Leaflet, x ½.
4. Flowering branchlet, x ½.
5. Staminate flower, back view, enlarged.
6. Pistillate flower, enlarged.
7. Fruit, x ½.

JUGLANDACEAE

Black Walnut

Juglans nigra L.

HABIT.—A large tree 50-75 feet high, with a massive trunk 2-5 feet in diameter; forming an open, capacious crown of heavy branches and coarse branchlets.

LEAVES.—Alternate, compound, 1-2 feet long. Leaflets 13-23, the terminal often lacking, 2-4 inches long and one-half as broad; sessile; ovate-lanceolate, taper-pointed; sharp-serrate; thin; yellow-green and glabrous above, lighter and soft-pubescent beneath. Petioles stout, pubescent. Foliage aromatic when bruised.

FLOWERS.—May, with the leaves; monoecious; the staminate in cylindrical, greenish, drooping catkins 3-5 inches long; calyx 6-lobed, borne on a hairy bract; corolla 0; stamens numerous, with purple anthers; the pistillate solitary or several on a common peduncle, about ¼ inch long, their bracts and bractlets hairy; calyx 4-lobed, pubescent; corolla 0; styles and stigmas 2.

FRUIT.—October; globose, 1½-2 inches in diameter, smooth, not viscid; solitary or borne in clusters of 2-3; nuts with irregularly furrowed shell, inclosing a sweet, edible kernel; aromatic.

WINTER-BUDS.—Terminal bud ⅓ inch long, ovoid, obliquely blunt, slightly flattened, silky-tomentose.

BARK.—Twigs brownish and hairy, becoming darker and smooth; thick, brownish or blackish on the trunk and deeply furrowed by broad, rounded ridges.

WOOD.—Heavy, hard, strong, close-grained, very durable in contact with the soil, rich dark brown, with thin, lighter colored sapwood.

NOTES.—The black walnut was once very abundant, especially in the Mississippi basin, where it grew to a height of 150 feet. It is valued for its nuts and beautiful wood. It prefers rich bottom-lands and fertile hillsides. The leaves appear late and fall early. One great drawback to its use in ornamental planting is the fact that it is so often infested with caterpillars.

THE HICKORIES

The hickories are stately trees, quite generally distributed throughout the United States. There are eight species, all peculiar to America, several of which produce edible nuts. Among the latter are the shellbark hickory in the north and the pecan in the south.

The flowers, arranged in catkins of the two kinds, appear in late spring after the unfolding of the leaves.

The wood of all these trees is heavy, tough and durable. It is used for axe handles, agricultural implements, and in places where strength and elasticity are required it is almost unrivaled.

The hickories frequently but erroneously are termed "walnuts" in the popular language of New England. The true walnuts, of which the butternut and black walnut are the American representatives, differ from the hickories, although they are closely related.

SUMMER KEY TO THE SPECIES OF CARYA

a. Bark of trunk essentially smooth, not deeply furrowed nor shaggy; husk of fruit less than ⅛ inch thick.

b. Leaflets usually 5-7, glabrous beneath, the upper 2-2½ inches broad; buds dome-shaped, greenish; kernel of nut sweet, **C. glabra,** p. 89.

bb. Leaflets usually 7-11, more or less downy beneath, the upper 1-1½ inches broad; buds long-pointed, flattish, bright yellow; kernel of nut bitter ....**C. cordiformis,** p. 91.

aa. Bark of trunk deeply furrowed or shaggy; husk of fruit more than ⅛ inch thick.

b. Twigs more or less pubescent; bark not shaggy; leaflets 5-7, more or less pubescent beneath; buds densely hairy, **C. alba,** p. 87.

bb. Twigs tending to be glabrous; bark distinctly shaggy; leaflets usually 5, glabrous beneath; buds glabrous or nearly so, **C. ovata,** p. 85.

WINTER KEY TO THE SPECIES OF CARYA

a. Bark of trunk essentially smooth, not deeply furrowed nor shaggy; husk of fruit less than ⅛ inch thick.

b. Terminal bud narrow, long-pointed, flattish, bright yellow, about ¾ inch long; kernel of nut bitter.......**C. cordiformis,** p. 91.

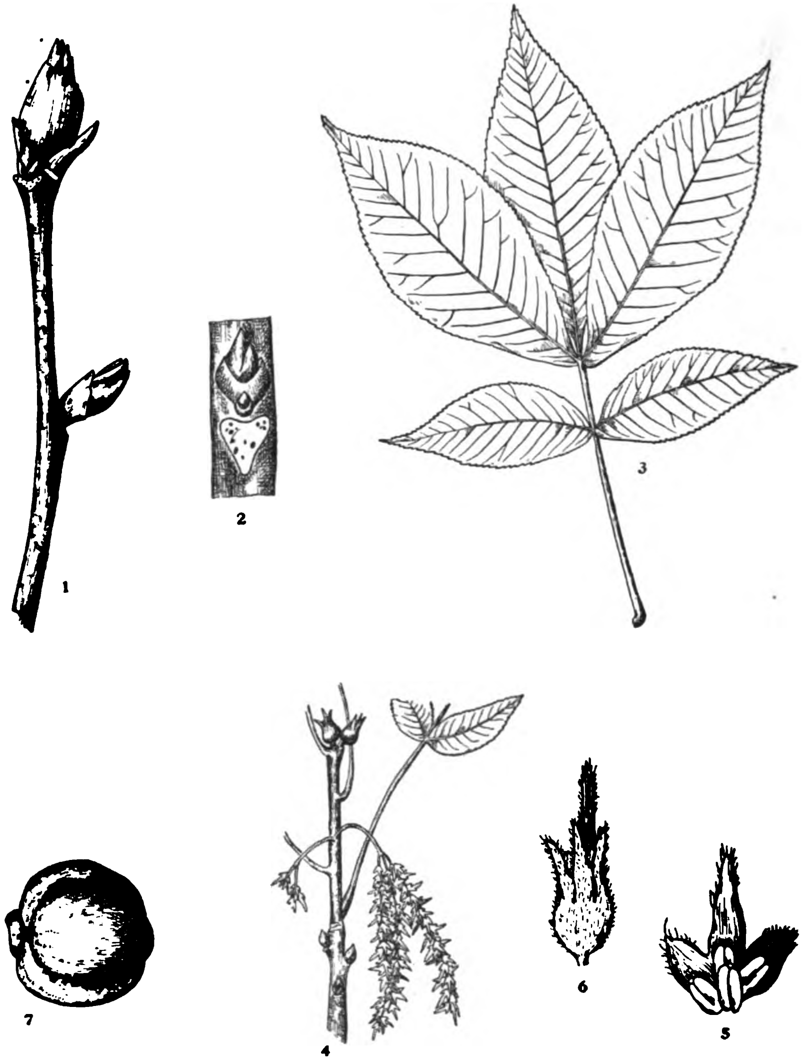
bb. Terminal bud broad, dome-shaped, greenish, ¼-½ inch long; kernel of nut sweet ....**C. glabra,** p. 89.

aa. Bark of trunk deeply furrowed or shaggy; husk of fruit more than ⅛ inch thick.

b. Twigs more or less pubescent; buds densely hairy, the outer bud-scales deciduous in autumn; bark not shaggy..**C. alba,** p. 87.

bb. Twigs tending to be glabrous; buds glabrous or nearly so, the outer bud-scales not deciduous in autumn; bark distinctly shaggy ....**C. ovata,** p. 85.

Shellbark Hickory. Shagbark Hickory



(Mich. Trees).

1. Winter twig, x 1.
2. Portion of twig, enlarged.
3. Leaf, x ⅓.
4. Flowering branchlet, x ½.
5. Staminate flower, enlarged.
6. Pistillate flower, enlarged.
7. Fruit, x ½.

JUGLANDACEAE

Shellbark Hickory. Shagbark Hickory

Carya ovata (Mill.) K. Koch [Hicoria ovata (Mill.) Britt.] [Carya alba Nutt.]

HABIT.—A tree 50-75 feet high, with a slender, columnar trunk 1-2 feet in diameter; forming a narrow, somewhat open crown of stout, slightly spreading limbs and stout branchlets.

LEAVES.—Alternate, compound, 8-14 inches long. Leaflets usually 5, the upper 5-7 inches long and 2-3 inches broad; sessile, except the terminal; obovate to oblong-lanceolate; finely serrate; thick and firm; glabrous, dark green above, paler beneath and glabrous or puberulous. Petioles stout, smooth or hairy. Foliage fragrant when crushed.

FLOWERS.—May-June, after the leaves; monoecious; the staminate hairy, greenish, in pendulous, ternate catkins 4-5 inches long, on a common peduncle about 1 inch long; scales 3-parted, bristle-tipped; stamens 4, with bearded, yellow anthers; the pistillate in 2-5-flowered spikes, ⅓ inch long, brown-tomentose; calyx 4-lobed, hairy; corolla 0; stigmas 2, large, fringed.

FRUIT.—October; globular, 1-2 inches long, with thick husk separating completely; nut usually 4-ridged, with thick shell and large, sweet, edible kernel.

WINTER-BUDS.—Terminal bud ½-¾ inch long, broadly ovoid, obtuse, dark brown, pale-tomentose or nearly glabrous.

BARK.—Twigs brownish, more or less downy, becoming smooth and grayish; thick and grayish on old trunks, separating into thick strips 1-3 feet long, free at one or both ends, giving a characteristic shaggy appearance. Plate II.

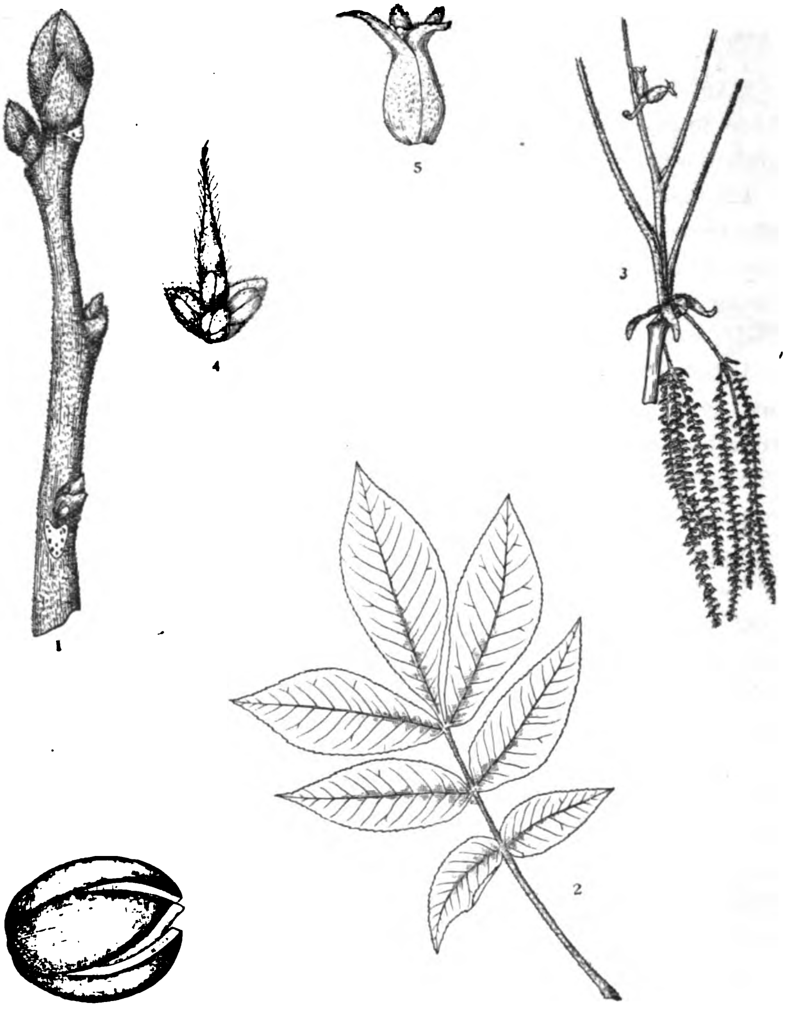
WOOD.—Heavy, very hard and strong, tough, close-grained, elastic, light brown, with thin, whitish sapwood. Page 229.

DISTRIBUTION.—Frequent in the lower altitudes west of the Green mountains; known in the Connecticut valley as far north as Bellows Falls; a large grove on the south side of Bald Mountain in Shrewsbury at an altitude of about 1,500 feet.

HABITAT.—Prefers light, well-drained, loamy soil; low hillsides; river-banks.

NOTES.—The shellbark hickory is one of our most attractive trees. It is known to every boy who lives in its range by its shaggy bark and its excellent nuts.

Mocker Nut. White Heart Hickory



(Mich. Trees).

1. Winter twig, x 1.
2. Leaf, x ⅓.
3. Flowering branchlet, x ½.
4. Staminate flower, enlarged.
5. Pistillate flower, enlarged.
6. Fruit, x ½.

JUGLANDACEAE

Mocker Nut. White Heart Hickory

Carya alba (L.) K. Koch [Hicoria alba (L.) Britt.] [Carya tomentosa Nutt.]

HABIT.—A tree 50-70 feet high, with a trunk diameter of 1-2½ feet; forming a wide crown of strong, upright branches and stout branchlets.

LEAVES.—Alternate, compound, 8-12 inches long. Leaflets usually 5-7, sometimes 9, the upper 5-8 inches long, 3-4 inches broad; sessile, except the terminal; oblong- to obovate-lanceolate; minutely or sometimes coarsely serrate; thick and firm; lustrous, dark yellow-green above, paler and more or less pubescent beneath. Petioles pubescent. Foliage fragrant when crushed.

FLOWERS.—May-June, after the leaves; monoecious; the staminate in pendulous, ternate catkins 4-5 inches long, slender, green, hairy; scales 3-lobed, hairy; stamens 4-5, with red anthers; the pistillate in crowded, 2-5-flowered, tomentose spikes; calyx toothed, hairy; corolla 0; stigmas 2, hairy.

FRUIT.—October; globose to globose-oblong, 1½-2 inches long, with thick husk splitting nearly to the base; nut 4-ridged, red-brown, with very thick, hard shell and small, sweet kernel.

WINTER-BUDS.—Terminal bud ½-¾ inch long, broadly ovoid, red-brown, pilose; outermost scales fall in early autumn.

BARK.—Twigs at first brown-tomentose, becoming smooth and grayish; on the trunk thick, hard, grayish, slightly ridged by shallow, irregular fissures, becoming rugged on very old trunks.

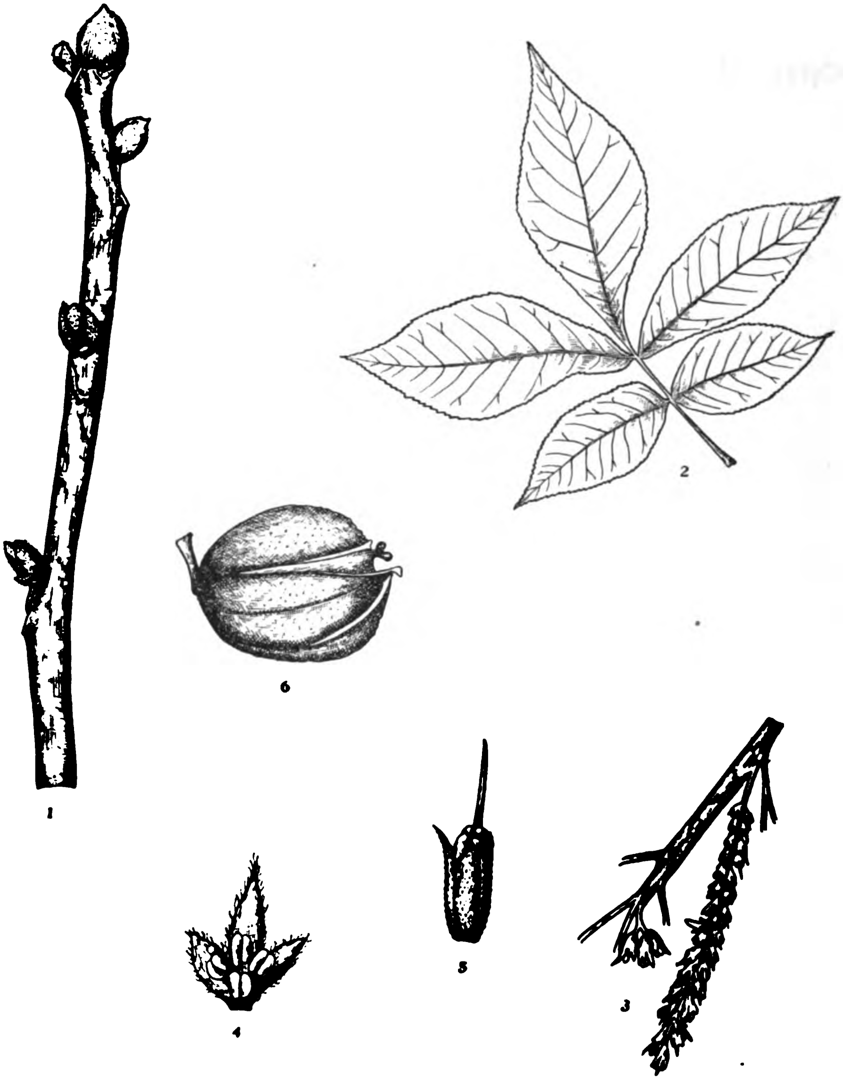
WOOD.—Very heavy, hard, strong, tough, close-grained, elastic, dark brown, with thick, whitish sapwood.

DISTRIBUTION.—Reported from Burlington and West Haven; probably occurs in other localities in the lower altitudes of the southern half of the State.

HABITAT.—Prefers rich, well-drained soil, but grows well in various situations, if they are not too wet.

NOTES.—This tree probably is not distinguished by most observers from *C. ovata,* which it closely resembles; there is need of further and more thorough investigation of this species.

Pignut



(Mich. Trees).

1. Winter twig, x 1.
2. Leaf, x ¼.
3. Flowering branchlet, x 1.
4. Staminate flower, enlarged.
5. Pistillate flower, enlarged.
6. Fruit, x 1.

JUGLANDACEAE

Pignut

Carya glabra (Mill.) Spach. [Hicoria glabra (Mill.) Britt.] [Carya porcina Nutt.]

HABIT.—A tree usually 50-60 feet high, with a trunk diameter of 1-3 feet; forming a low, rather narrow, open crown of slender, often contorted branches.

LEAVES.—Alternate, compound, 8-12 inches long. Leaflets usually 5-7, the upper 3-6 inches long, 2-2½ inches broad; sub-sessile, except the terminal; oblong to obovate-lanceolate, taper-pointed; sharply serrate; thick and firm; glabrous, dark yellow-green above, paler beneath. Petioles long, slender, glabrous or pubescent. Foliage fragrant when crushed.

FLOWERS.—May-June, after the leaves; monoecious; the staminate in pendulous, ternate catkins 3-7 inches long, slender, yellow-green, tomentose; scales 3-lobed, nearly glabrous; stamens 4, with orange anthers; the pistillate in crowded, 2-5-flowered spikes, ¼ inch long; calyx 4-toothed, hairy; corolla 0; stigmas 2, yellow.

FRUIT.—October; variable in size and shape, 1½-2 inches long, with thin husk splitting half-way and sometimes nearly to the base; nut obscurely 4-ridged, with thin or thick, hard shell and small, sweet or slightly bitter kernel which is hard to remove.

WINTER-BUDS.—Terminal bud ¼-½ inch long, dome-shaped, greenish or grayish, smooth or finely downy.

BARK.—Twigs greenish, nearly glabrous, becoming reddish, and finally grayish; thick, hard and grayish on the trunk, with a firm, close surface divided by small fissures and sometimes broken into plates. Plate II.

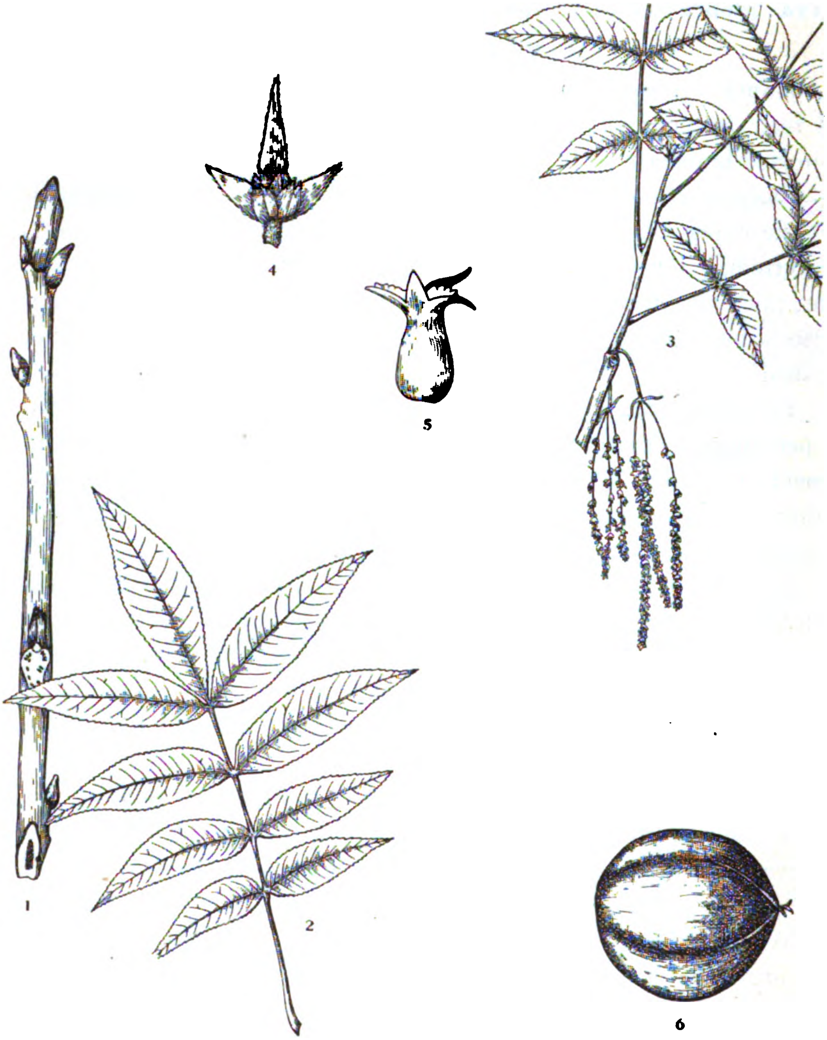
WOOD.—Heavy, hard, very strong, tough, close-grained, elastic, dark brown, with thick, whitish sapwood.

DISTRIBUTION.—Occurs in the southern portion of Vermont.

HABITAT.—Prefers deep, rich loam, but grows in any well-drained soil; dry ridges and hillsides.

NOTES.—This is a common tree in the Hoosic valley, Pownal, and a large grove occurs on the shore of Lake Bomoseen, West Castleton (Eggleston). There are a few trees near the Hubbardton line in East Castleton (G. H. Ross). In the Connecticut valley it is abundant on the hills near the river in the vicinity of the Massachusetts line, but is not common above Bellows Falls (Flint). Observers of trees in southern Vermont should strive further to increase our knowledge of its distribution.

Bitternut Hickory



(Mich. Trees).

1. Winter twig, x 1.
2. Leaf, x ⅓.
3. Flowering branchlet, x ½.
4. Staminate flower, enlarged.
5. Pistillate flower, enlarged.
6. Fruit, x 1.

JUGLANDACEAE

Bitternut Hickory

Carya cordiformis (Wang.) K. Koch [Hicoria minima (Marsh.) Britt.] [Carya amara Nutt.]

HABIT.—A tall, slender tree 50-75 feet high, with a trunk diameter of 1-2½ feet; forming a broad crown of slender, stiff, upright branches, widest near the top.

LEAVES.—Alternate, compound, 6-10 inches long. Leaflets 5-11, the upper 4-6 inches long and one-fourth as broad; sessile, except the terminal; lanceolate to oblong-lanceolate, long-pointed; coarsely serrate; thin and firm; glabrous, bright green above, paler and more or less downy beneath. Petioles slender, hairy. Foliage fragrant when crushed.

FLOWERS.—May-June, after the leaves; monoecious; the staminate slightly pubescent, in pendulous, ternate catkins 3-4 inches long, on a common peduncle about 1 inch long; scale 3-lobed, hairy; stamens 4, with bearded, yellow anthers; the pistillate in 2-5-flowered spikes, ½ inch long, scurfy-tomentose; calyx 4-lobed, pubescent; corolla 0; stigmas 2, greenish.

FRUIT.—October; obovate to globular, about 1 inch long, coated with yellow, scurfy pubescence, with very thin husk splitting half-way to the base, with sutures winged at the top; nut quite smooth, with thin shell and small, bitter kernel.

WINTER-BUDS.—Terminal bud about ¾ inch long, long-pointed, flattish, granular-yellow; lateral buds more or less 4-angled.

BARK.—Twigs greenish and more or less downy, becoming brownish, and finally grayish; gray, close, smooth on the trunk, often reticulately ridged, but rarely broken into plates. Plate III.

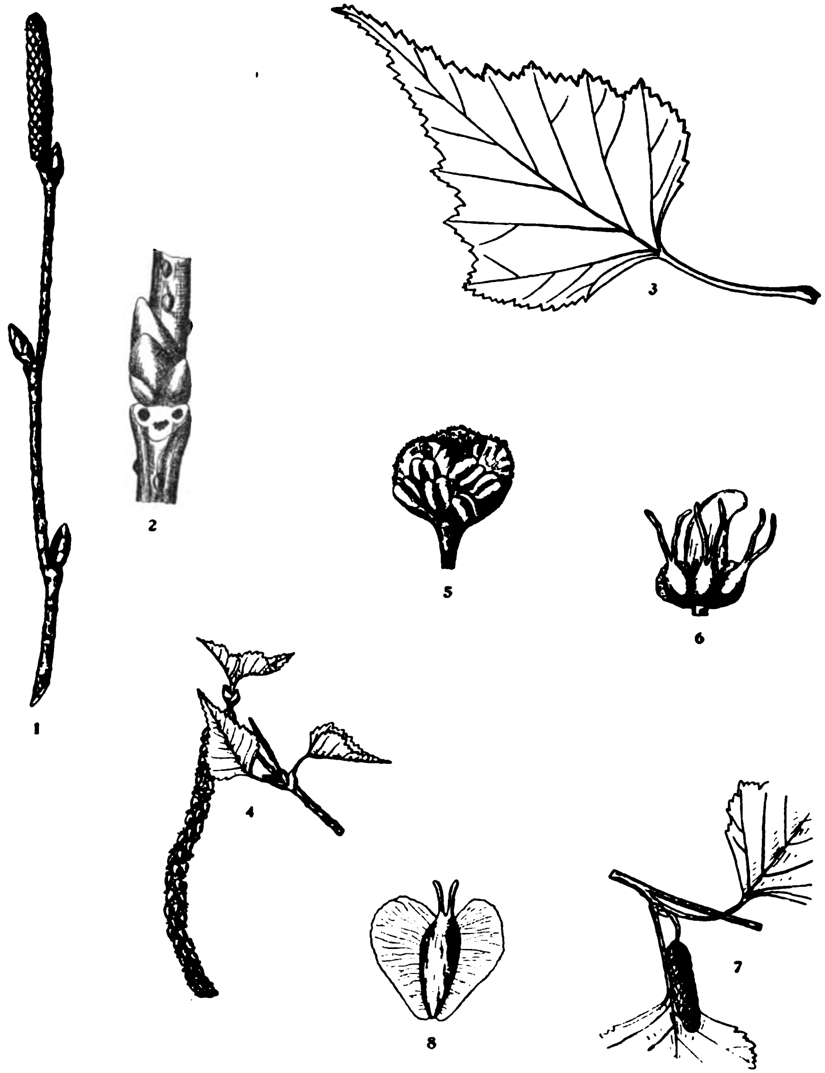
WOOD.—Heavy, very hard, strong, tough, close-grained, dark brown, with thick, lighter colored sapwood.

DISTRIBUTION.—Frequent in the lower altitudes west of the Green mountains and known in the Connecticut valley as far north as Hartland.

HABITAT.—Prefers a rich, loamy soil; low, wet woods; along the borders of streams.

NOTES.—The bitternut grows most rapidly of all the hickories, but it is apt to show dead branches. It should be propagated from the seed, as it is not easily transplanted. The yellow buds at once distinguish it from all other hickories.

White Birch. Gray Birch. Old Field Birch



1. Winter twig, x 1.
2. Portion of twig, enlarged.
3. Leaf, x 1.
4. Flowering branchlet, x ½.
5. Staminate flower, enlarged.
6. Pistillate flower, enlarged.
7. Fruiting branchlet, x ½.
8. Fruit, enlarged.

BETULACEAE

American Hop Hornbeam. Leverwood

Ostrya virginiana (Mill.) K. Koch

HABIT.—A small tree usually 20-30 feet high, with a trunk diameter of 8-12 inches; forming a broad, rounded crown of many long, slender branches and a slender, stiff spray.

LEAVES.—Alternate, simple, 3-5 inches long, about one-half as broad; oblong-ovate; sharply doubly serrate; thin and very tough; dull, dark green above, paler and more or less pubescent beneath; petioles short, slender, pubescent.

FLOWERS.—May, with the leaves; monoecious; the staminate in drooping, cylindrical catkins from wood of the previous season, usually in threes; stamens 3-14, crowded on a hairy torus; the pistillate in erect, lax catkins on the season's shoots, usually in pairs, each flower inclosed in a hairy, sac-like involucre.

FRUIT.—September; strobiles, resembling clusters of hops, 1-2 inches long, borne on slender, hairy stems; nuts small and flat, inclosed by sac-like involucres.

WINTER-BUDS.—Terminal but absent; lateral buds ⅛-¼ inch long, ovoid, acute, red-brown.

BARK.—Twigs at first light green, becoming lustrous, red-brown, and finally dull dark brown; thin, gray-brown on the trunk, very narrowly and longitudinally ridged. Plate III.

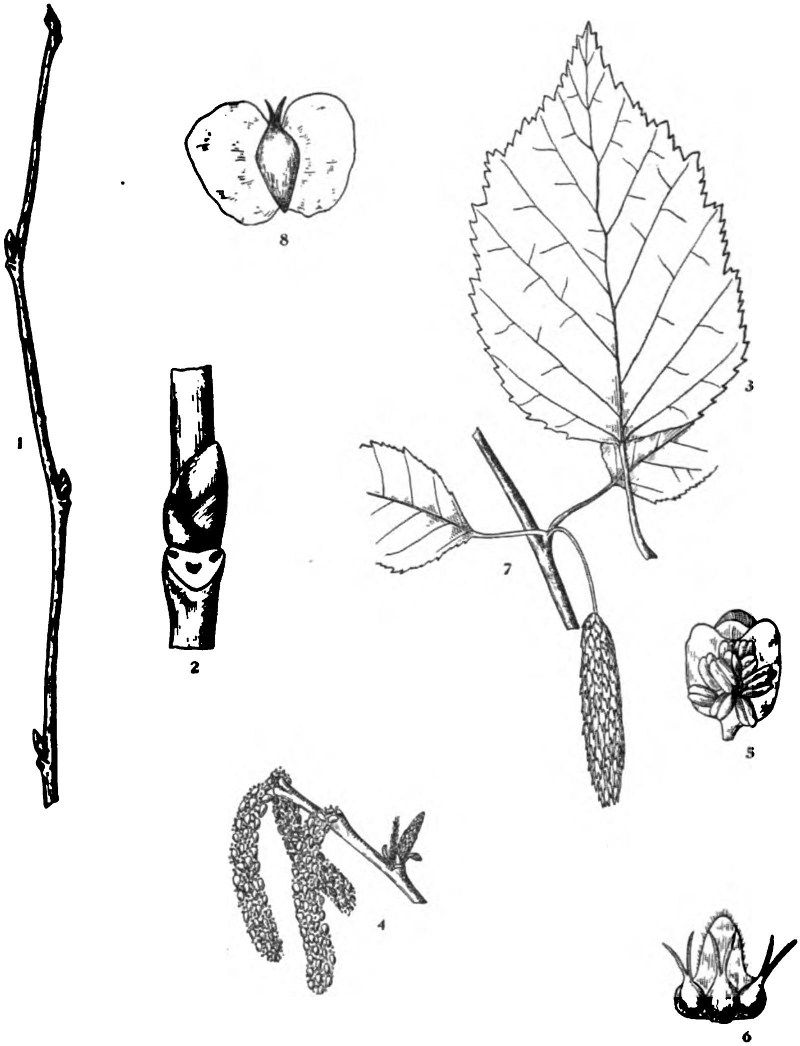
WOOD.—Heavy, very strong and hard, tough, close-grained, durable, light red-brown, with thick, whitish sapwood.

DISTRIBUTION.—Common to both valleys and mountains of Vermont, but more abundant in the western and southern portions.

HABITAT.—Rich woods; open woods; slopes and ridges.

NOTES.—Hornbeams sometimes are mistaken and transplanted for elms, owing to the general similarity in the appearances of the young trees. The leaves of the hornbeam, however, are nearly symmetrical at the base, while those of the elm are more unequally developed. In late summer the hornbeam is easily distinguished by its fruit hanging in hop-like heads. The hornbeam is distributed, quite generally, both in the valleys and the mountainous parts of Vermont, but is most common in western and southern portions. It is a small tree. The wood is very strong, tough and durable in contact with the soil, hence the names ironwood, leverwood. It is used for levers, mallets and for fencing materials.

Paper Birch. Canoe Birch. White Birch



(Mich. Trees).

1. Winter twig, x 1.
2. Portion of twig, enlarged.
3. Leaf, x 1.
4. Flowering branchlet, x ½.
5. Staminate flower, enlarged.
6. Pistillate flower, enlarged.
7. Fruiting branchlet, x ½.
8. Fruit, x 3½.

BETULACEAE

Paper Birch. Canoe Birch. White Birch

Betula alba papyrifera (Marsh.) Spach. [Betula papyrifera Marsh.]

HABIT.—A tree 50-75 feet high, with a trunk diameter of 1-3 feet, forming in youth a compact, pyramidal crown of many slender branches, becoming in old age a long, branchless trunk with a broad, open crown, composed of a few large limbs ascending at an acute angle, with almost horizontal branches and a slender, flexible spray.

LEAVES.—Alternate, simple, 2-3 inches long, 1½-2 inches broad; ovate; coarsely, more or less doubly serrate; thick and firm; glabrous, dark green above, lighter beneath, covered with minute black glands; petioles stout, yellow, glandular, glabrous or pubescent.

FLOWERS.—April-May, before the leaves; monoecious; the staminate catkins clustered or in pairs, 3-4 inches long, slender, pendent, brownish; the pistillate catkins about 1½ inches long, slender, erect or spreading, greenish; styles bright red.

FRUIT.—Ripens in autumn; long-stalked, cylindrical, glabrous, drooping strobiles, about 1½ inches long; scales hairy on the margin; nut narrower than its wing.

WINTER-BUDS.—Terminal bud absent; lateral buds ¼ inch long, narrow-ovoid, acute, flattish, slightly resinous, usually divergent.

BARK.—Twigs dull red, becoming lustrous, orange-brown; bark of trunk and large limbs cream-white and lustrous on the outer surface, bright orange on the inner, separating freely into thin, papery layers, becoming furrowed and almost black near the ground. Plate III.

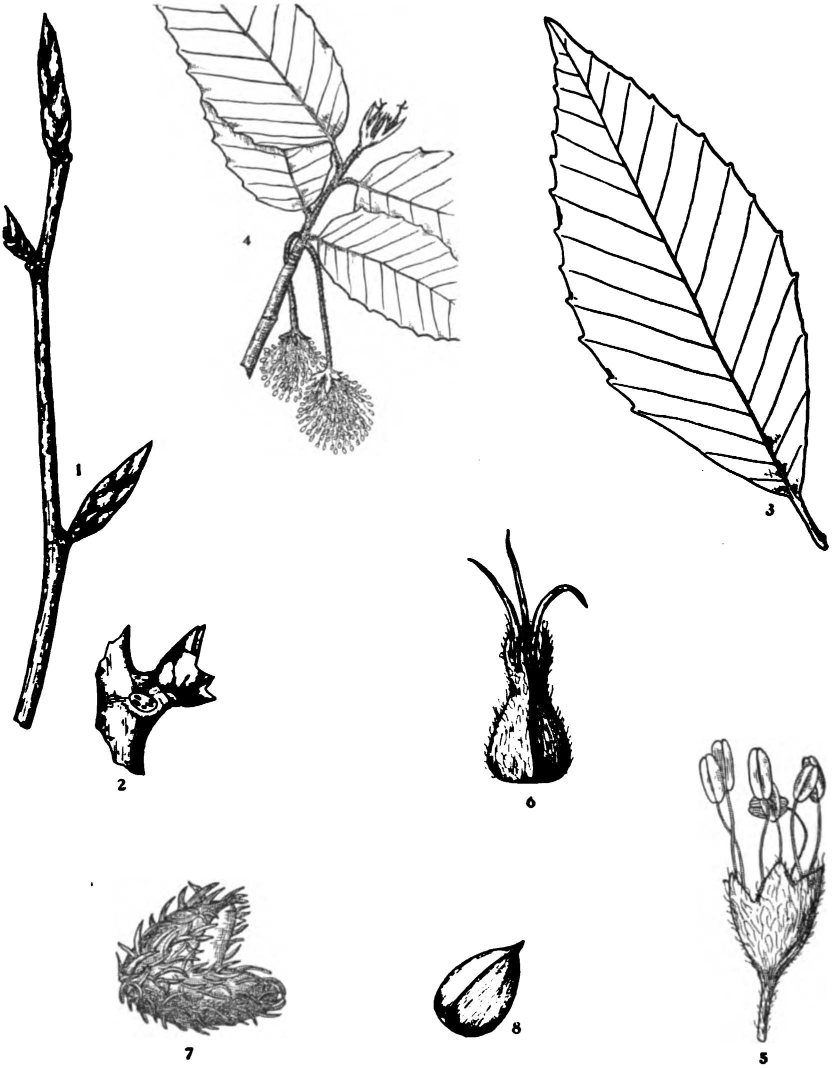
WOOD.—Light, hard, strong, tough, very close-grained, light brown tinged with red, with thick, whitish sapwood.

DISTRIBUTION.—Common throughout Vermont.

HABITAT.—Prefers rich, moist hillsides; borders of streams, lakes and swamps; mountain slopes.

NOTES.—The paper birch is often intermingled with the white birch and is confused popularly with it, although careful observation reveals many characteristics by which the two may be distinguished. The paper birch is a larger tree than the white birch and more widely distributed. The two species are similar in the chalky whiteness of the bark, but that of the white birch clings closely so that it cannot be separated in large layers, whereas the peculiar character of the paper birch is the ease with which ample sheets of the beautiful corky layers may be removed.

Beech



(Mich. Trees).

1. **Winter twig, x 1.**
2. **Portion of twig, enlarged.**
3. **Leaf, x ½.**
4. **Flowering branchlet, x ¾.**
5. **Staminate flower, enlarged.**
6. **Pistillate flower, enlarged.**
7. **Bur, opened, x 1.**
8. **Nut, x 1.**

FAGACEAE

Beech

Fagus grandifolia Ehrh. [Fagus atropunicea (Marsh.) Sudw.] [Fagus ferruginea Ait.] [Fagus americana Sweet]

HABIT.—A beautiful tree, rising commonly to a height of 50-75 feet, with a trunk diameter of 2-4 feet; in the forest, tall and slender, with short branches forming a narrow crown, in the open with a short, thick trunk and numerous slender, spreading branches, forming a broad, compact, rounded crown.

LEAVES.—Alternate, simple, 3-5 inches long, one-half as broad; oblong-ovate, acuminate; coarsely serrate, a vein terminating in each tooth; thin; dark blue-green above, light yellow-green and very lustrous beneath; petioles short, hairy.

FLOWERS.—May, with the leaves; monoecious; the staminate in globose heads 1 inch in diameter, on long, slender, hairy peduncles, yellow-green; calyx campanulate, 4-7-lobed, hairy; corolla 0; stamens 8-10; the pistillate on short, hairy peduncles in 2-flowered clusters surrounded by numerous awl-shaped, hairy bracts; calyx urn-shaped, 4-5-lobed; corolla 0; ovary 3-celled; styles 3.

FRUIT.—Ripens in autumn; a prickly bur borne on stout, hairy peduncles, persistent on the branch after the nuts have fallen; nuts usually 3, ¾ inch long, sharply tetrahedral, brownish; sweet and edible.

WINTER-BUDS.—Nearly 1 inch long, very slender, cylindrical, gradually taper-pointed, brownish, puberulous.

BARK.—Twigs lustrous, olive-green, finally changing through brown to ashy gray; close, smooth, steel-gray on the trunk, often mottled by darker blotches and bands. Plate IV.

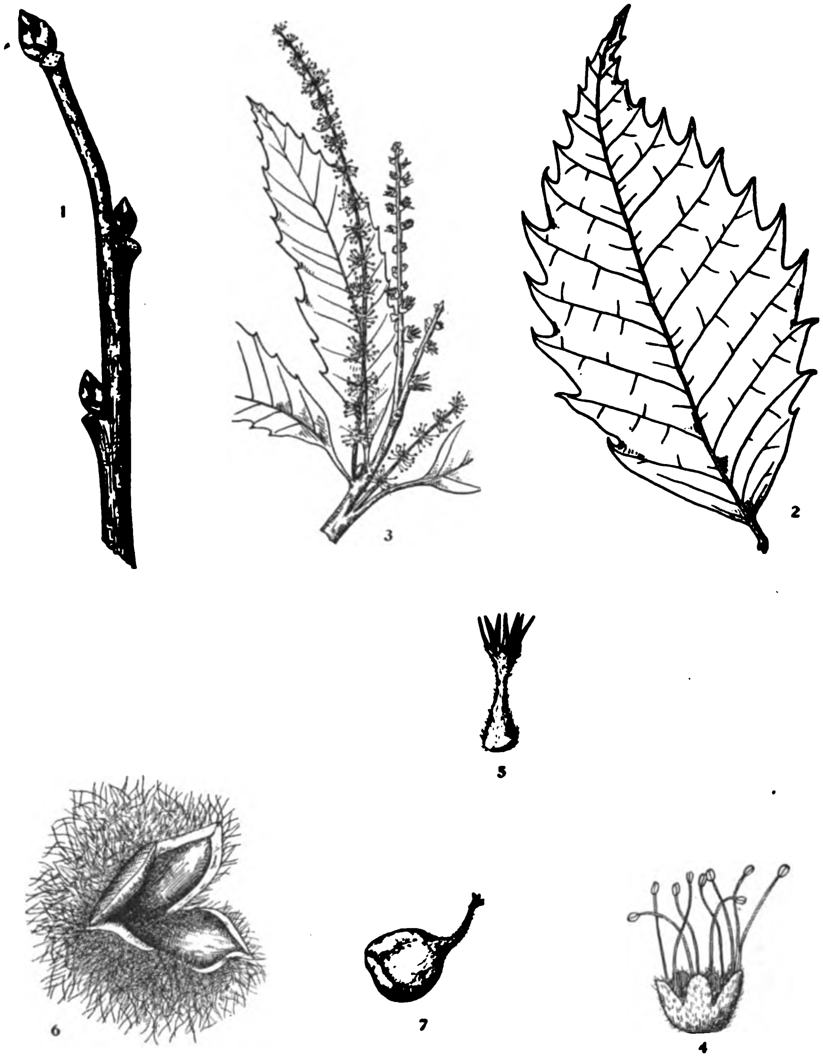
WOOD.—Hard, tough, strong, very close-grained, not durable, difficult to season, light or dark red, with thin, whitish sapwood. Page 227.

DISTRIBUTION.—Abundant throughout Vermont.

HABITAT.—Rich uplands; moist, rocky soil.

NOTES.—The beech, when growing in the forest, with its tall, graceful trunk, its smooth, gray bark and shiny leaves, is a handsome tree. It is not only one of the most common trees in Vermont, but also one of the most widely distributed in eastern North America. The drooping clusters of pollen-bearing flowers and the short, stout ovule-bearing heads open under the newly spreading leaves in early May. The burs open and the nuts fall with the first frosts of autumn.

Chestnut



(Mich. Trees).

1. Winter twig, x 1.
2. Leaf, x ½.
3. Flowering branchlet, x ½.
4. Staminate flower, enlarged.
5. Pistillate flower, enlarged.
6. Prickly bur, opened, x ½.
7. Nut, x ½.

FAGACEAE

Chestnut

Castanea dentata (Marsh.) Borkh. [Castanea vesca, v. americana Michx.] [Castanea sativa, v. americana Sarg.]

HABIT.—A tree 60-80 feet high, forming a short, straight trunk 2-4 feet in diameter, divided not far above the ground into several stout, horizontal limbs and forming a broad, open, rounded crown.

LEAVES.—Alternate, simple, 6-8 inches long, 2-3 inches broad; oblong-lanceolate, long-pointed at the apex; coarsely serrate with stout, incurved, glandular teeth; thin; dull yellow-green above, lighter beneath, glabrous; petioles short, stout, puberulous.

FLOWERS.—July, after the leaves; monoecious; the staminate catkins 6-8 inches long, slender, puberulous, bearing 3-7-flowered cymes of yellow-green flowers; calyx 6-cleft, pubescent; stamens 10-20; the androgynous catkins 2½-5 inches long, puberulous, bearing 2-3 prickly involucres of pistillate flowers near their base; calyx campanulate, 6-lobed; styles 6.

FRUIT.—Ripens in autumn; round, thick, prickly burs, about 2 inches in diameter, containing 1-3 nuts; nuts compressed, brownish, coated with whitish down at the apex; sweet and edible.

WINTER-BUDS.—Terminal bud absent; lateral buds ¼ inch long, ovoid, acute, brownish.

BARK.—Twigs lustrous, yellow-green, becoming olive-green and finally dark brown; old trunks gray-brown, with shallow fissures and broad, flat ridges. Plate IV.

WOOD.—Light, soft, coarse-grained, weak, easily split, very durable in contact with the soil, red-brown, with very thin, lighter colored sapwood.

DISTRIBUTION.—Frequent in the Connecticut valley as far north as Bellows Falls and in southwestern Vermont; occasional as far north as Windsor, West Rutland, Leicester, Burlington, Colchester and Stowe. Planted as far north as Franklin.

HABITAT.—Rocky woods and hillsides.

NOTES.—The chestnut probably will grow in all parts of Vermont. It is a rapid grower and lives to a great age but is subject to a disease which threatens extermination in this country. The leaves are shiny and graceful, from six to eight inches long. When they are nearly grown, long, stiff catkins of fragrant, greenish-yellow flowers appear. These bear the pollen, the ovule-bearing flowers being smaller, enclosed in bur-like scales. The nuts, two or three in a bur, ripen in October.

THE OAKS

The oaks, abundant throughout the northern hemisphere, are remarkable for their massive trunks, their thick, rugged bark and large, strong roots. They are distinguished from all other trees by their cupped fruit, but many who have seen these fruits have not noticed the small, scaly masses of flowers which produce them. The pollen-bearing flowers are found on the same tree, but are arranged in long, slender catkins consisting of a cluster of from three to twelve stamens. Some of the oaks, including the red and black, do not mature their fruit until the second year.

Oak timber is of great commercial value, being used for a variety of purposes. For strength, toughness and durability combined, it is unsurpassed.

The oak genus is a large one. Nine species and two hybrids are included in the last flora of Vermont. They are extremely difficult to tell apart and the late Doctor Pringle remarked that after 25 years of study he did not know the oaks of Vermont. This genus varies greatly and some valuable work could be done in studying its variations.

Only the tree oaks are given in the following keys.

SUMMER KEY TO THE SPECIES OF QUERCUS

a. Leaves deeply cut or lobed.

b. Leaf-lobes acute, bristle-tipped; fruit maturing in the second season.

c. Lower surface of leaves more or less pubescent; buds hoary-tomentose; bark of trunk deeply furrowed and scaly; inner bark yellow; nut ½-¾ inch long, inclosed for about one-half of its length by a deep, turbinate cup.... **Q. velutina,** p. 127.

cc. Lower surface of leaves glabrous or nearly so; buds glabrous; bark of trunk smoothish or only slightly fissured; inner bark whitish or pinkish; nut about 1 inch long, inclosed only at the base by a shallow, saucer-shaped cup.. **Q. rubra,** p. 125.

bb. Leaf-lobes rounded, not bristle-tipped; fruit maturing in the first season.

c. Leaves cut nearly to the midrib by a pair of deep sinuses near the middle of the leaf; branches corky-ridged; nut usually ¾-1½ inches long, deeply seated in a large, conspicuously fringed cup .... **Q. macrocarpa,** p. 117.

cc. Leaves not cut by a pair of deep sinuses; branches not corky-ridged; nut about ¾ inch long, about one-fourth inclosed by a thin, tomentose, warty cup............... **Q. alba,** p. 115.

aa. Leaves not deeply cut nor lobed.

b. Bark on branches breaking into large, papery scales which curl back; acorns on stems 1-4 inches long; tree typical of swamps. **Q. bicolor,** p. 119.

bb. Bark on branches close, not breaking into large, papery scales; acorns sessile or on stalks less than 1 inch long; trees not typical of swamps.

c. Bark of trunk thin, not deeply fissured into inverted V-shaped ridges, flaky, silvery gray or ash colored; leaves coarsely toothed .... **Q. muhlenbergii,** p. 121.

cc. Bark of trunk thick, deeply fissured into inverted V-shaped ridges, not flaky, dark red-brown to nearly black; leaves coarsely crenate .... **Q. prinus,** p. 123.

WINTER KEY TO THE SPECIES OF QUERCUS

a. Terminal buds usually about ⅛ inch long.
  b. Twigs thick-tomentose; entire bud pale-pubescent; branches corky-ridged; cup of acorn conspicuously fringed at the rim, [1][1] **Q. macrocarpa,** p. 117.
  bb. Twigs glabrous; buds glabrous, or only slightly or partially pubescent; branches without corky ridges; cup of acorn not conspicuously fringed at the rim.
    c. Bark on branches breaking into large, papery scales which curl back; buds pilose above the middle; acorns on stems 1-4 inches long .... [1] **Q. bicolor,** p. 119.
    cc. Bark on branches not breaking into large, papery scales; buds glabrous; acorns sessile or very short-stalked.
      d. Buds conical, acute; bud-scales scarious on the margins; nut white-downy at the apex.... [1] **Q. muhlenbergii,** p. 121.
      dd. Buds broadly ovoid, obtuse; bud-scales not scarious on the margins; nut not white-downy at the apex, [1] **Q. alba,** p. 115.

aa. Terminal buds usually about ¼ inch long.
  b. Buds strictly glabrous throughout; bark of trunk smoothish or only slightly fissured, inner bark not bitter-tasting; nut inclosed only at the base by a shallow, saucer-shaped cup, [2][2] **Q. rubra,** p. 125.
  bb. Buds more or less pubescent or tomentose; bark of trunk deeply furrowed and roughish, inner bark bitter-tasting; nut inclosed for about one-half of its length by a deep, cup-shaped or turbinate cup.
    c. Buds hoary-tomentose, obtuse at the apex, strongly angled; inner bark of trunk yellow; acorns maturing in autumn of second season; nut ½-¾ inch long, with bitter kernel, [2] **Q. velutina,** p. 127.
    cc. Buds slightly hairy, sharp-pointed, not strongly angled; inner bark of trunk not yellow; acorns maturing in autumn of first season; nut 1-1½ inches long, with sweet kernel, [1] **Q. prinus,** p. 123.

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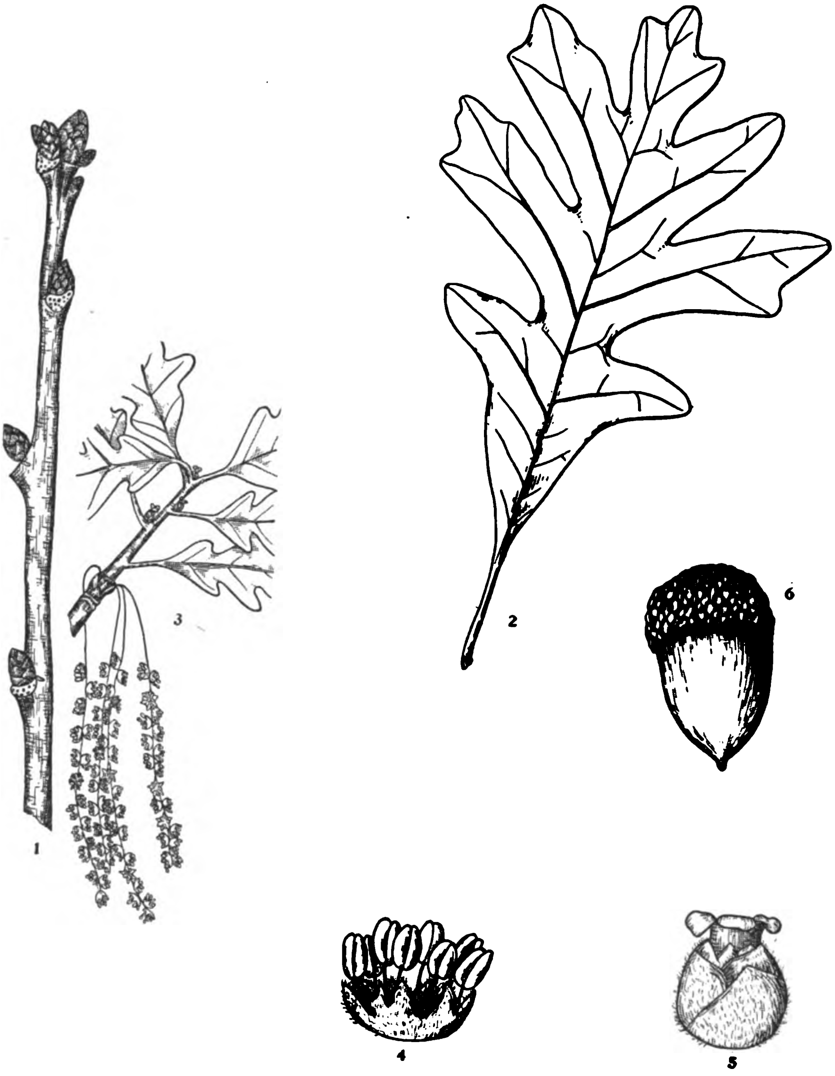
[1] [1] means that the acorns mature in the autumn of the first season, hence mature acorns will not be found on the tree, but on the ground beneath the tree.

[2] [2] means that the acorns mature in the autumn of the second season, hence immature acorns will be found on the last season's twigs, and mature acorns on the ground beneath the tree.

White Oak



(Mich. Trees).

1. Winter twig, x 1½.
2. Leaf, x ½.
3. Flowering branchlet, x ½.
4. Staminate flower, enlarged.
5. Pistillate flower, enlarged.
6. Fruit, x 1.

FAGACEAE

White Oak

Quercus alba L.

HABIT.—A large tree 50-75 feet high, with a trunk diameter of 2-4 feet; forming a short, thick trunk with stout, horizontal, far-reaching limbs, more or less gnarled and twisted in old age, and a broad, open crown.

LEAVES.—Alternate, simple, 5-9 inches long, about one-half as broad; obovate to oblong; 5-9-lobed, some with broad lobes and shallow sinuses, others with narrow lobes and deep, narrow sinuses, the lobes usually entire; thin and firm; glabrous, bright green above, pale or glaucous beneath; often persistent on the tree through the winter.

FLOWERS.—May, with the leaves; monoecious; the staminate in hairy catkins 2-3 inches long; the pistillate sessile or short-peduncled, reddish, tomentose; calyx campanulate, 6-8-lobed, yellow, hairy; corolla 0; stamens 6-8, with yellow anthers; stigmas red.

FRUIT.—Autumn of first season; sessile or short-stalked acorns; cup with small, brown-tomentose scales, inclosing one-fourth of the nut; nut oblong-ovoid, rounded at the apex, about ¾ inch long, light brown; kernel sweet and edible.

WINTER-BUDS.—Terminal bud ⅛ inch long, broadly ovoid, obtuse; scales smooth, dark red-brown.

BARK.—Twigs at first bright green, tomentose, later reddish, and finally ashy gray; thick, light gray or whitish on old trunks, shallowly fissured into broad, flat ridges. Plate IV.

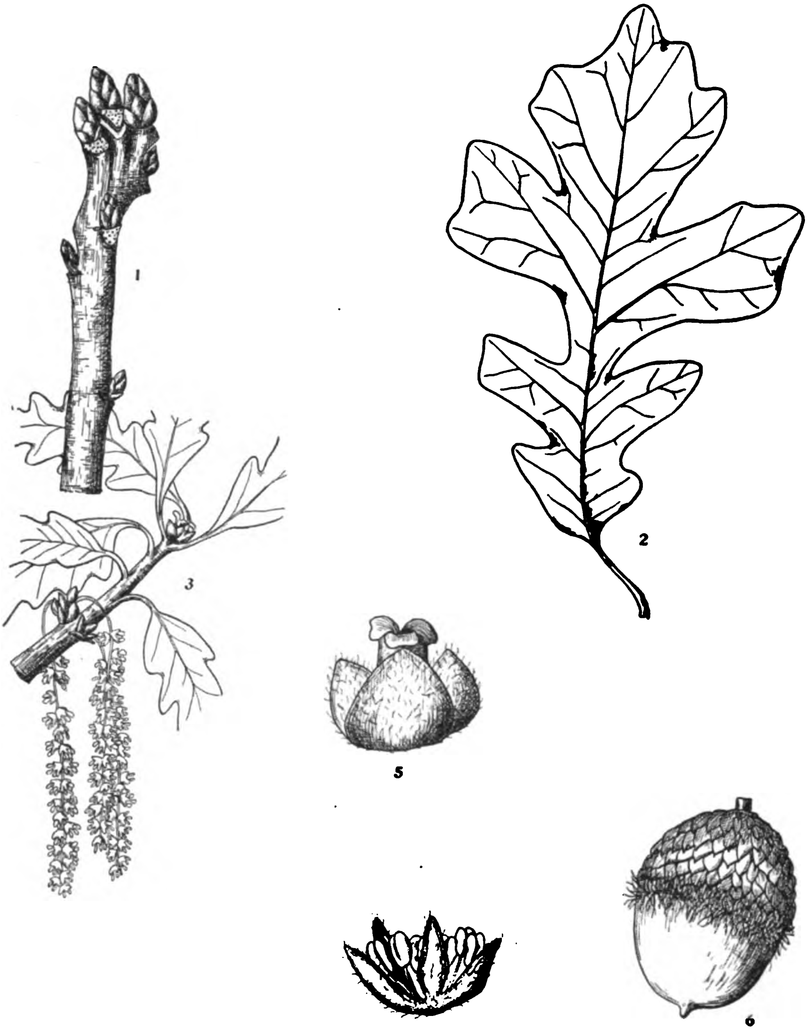
WOOD.—Very heavy, strong, hard, tough, close-grained, durable, light brown, with thin, light browh sapwood.

DISTRIBUTION.—Common west of the Green mountains; occurs sparingly in the Connecticut valley as far north as Wells River.

HABITAT.—Grows well in all but very wet soils, in all open exposures; dry woods.

NOTES.—The white oak is the most beautiful as well as the most useful of the oaks found in this part of the United States. Vermont has quite a generous supply of these trees in the Champlain valley. The tough, heavy wood of the white oak needs no recommendation. On account of the beauty of its grain and its capability of taking a high polish, it is used extensively for furniture and for interior finishing. The famous "Charter Oak" of Connecticut was of this species.

Bur Oak. Over-cup Oak. Mossy-cup Oak



(Mich. Trees).

1. Winter twig, x 2.
2. Leaf, x ⅓.
3. Flowering branchlet, x ½.
4. Staminate flower, enlarged.
5. Pistillate, enlarged.
6. Fruit, x 1.

FAGACEAE

Bur Oak. Over-cup Oak. Mossy-cup Oak

Quercus macrocarpa Michx.

HABIT.—A medium-sized tree 40-60 feet high, with a trunk 2-4 feet in diameter; great, spreading branches form a broad, rugged crown.

LEAVES.—Alternate, simple, 6-10 inches long and one-half as broad; obovate to oblong, wedge-shaped at the base; crenately lobed, usually cut nearly to the midrib by two opposite sinuses near the middle; thick and firm; dark green and shining above, pale pubescent beneath; petioles short, stout.

FLOWERS.—May, with the leaves; monoecious; the staminate in slender, hairy catkins 4-6 inches long; the pistillate sessile or short-stalked, reddish, tomentose; calyx 4-6-lobed, yellow-green, downy; corolla 0; stamens 4-6, with yellow anthers; stigmas bright red.

FRUIT.—Autumn of first season; sessile or short-stalked acorns; very variable in size and shape; cup typically deep, cup-shaped, tomentose, fringed at the rim, inclosing one-third or all of the nut; nut broad-ovoid, ½-1½ inches long, brownish, pubescent; kernel white, sweet and edible.

WINTER-BUDS.—Terminal bud ⅛ inch long, broadly ovoid or conical, red-brown, pale-pubescent.

BARK.—Twigs yellow-brown, thick-tomentose, becoming ash-gray or brownish; branches with corky ridges; thick and gray-brown on the trunk, deeply furrowed.

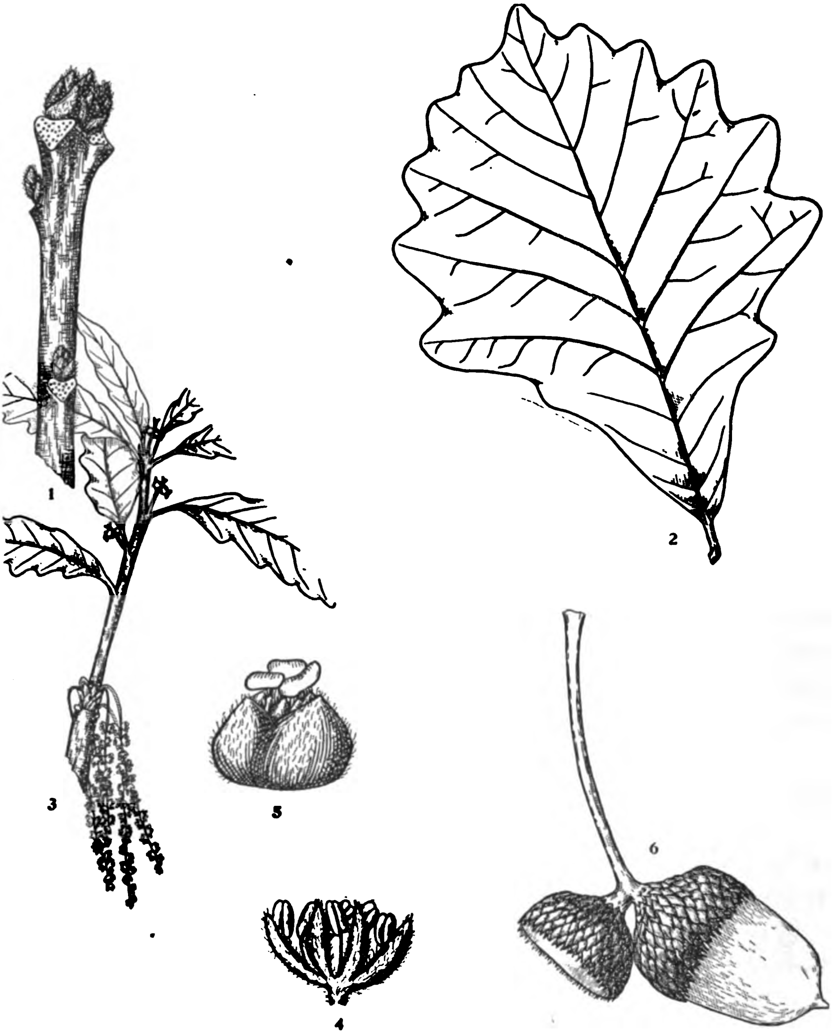
WOOD.—Heavy, hard, strong, tough, close-grained, very durable, brownish, with thin, pale sapwood.

DISTRIBUTION.—Occasional in the Champlain valley, more common in Addison county.

HABITAT.—Prefers rich, moist soil; bottom-lands.

NOTES.—The bur oak is easily recognized by its mossy cups. It is occasionally planted as an ornamental tree, but on account of its large size it is suitable only for parks and large estates. Commercially its wood is not distinguished from the white oak.

Swamp White Oak



(Mich. Trees).

1. Winter twig, x 2.
2. Leaf, x ½.
3. Flowering branchlet, x ½.
4. Staminate flower, enlarged.
5. Pistillate flower, enlarged.
6. Fruit, x 1.

FAGACEAE

Swamp White Oak

Quercus bicolor Willd. [Quercus platanoides (Lam.) Sudw.]

HABIT.—A medium-sized tree 40-60 feet high, with a trunk diameter of 2-3 feet; forming a rather open, rugged crown of tortuous, pendulous branches and short, stiff, bushy spray.

LEAVES.—Alternate, simple, 5-7 inches long, 3-5 inches broad; obovate to oblong-obovate; coarsely sinuate-crenate or shallow-lobed; thick and firm; dark green and shining above, whitish and more or less tomentose beneath; petioles stout, about ½ inch long.

FLOWERS.—May, with the leaves; monoecious; the staminate in hairy catkins 3-4 inches long; the pistillate tomentose, on long, tomentose peduncles, in few-flowered spikes; calyx deeply 5-9-lobed, yellow-green, hairy; corolla 0; stamens 5-8, with yellow anthers; stigmas bright red.

FRUIT.—Autumn of first season; acorns on pubescent stems 1-4 inches long, usually in pairs; cup cup-shaped, with scales somewhat loose (rim often fringed), inclosing one-third of the nut; nut ovoid, light brown, pubescent at the apex, about 1 inch long; kernel white, sweet, edible.

WINTER-BUDS.—Terminal bud ⅛ inch long, broadly ovoid to globose, obtuse; scales light brown, pilose above the middle.

BARK.—Twigs at first lustrous, green, becoming red-brown, finally dark brown and separating into large, papery scales which curl back; thick, gray-brown on the trunk, deeply fissured into broad, flat, scaly ridges. Plate IV.

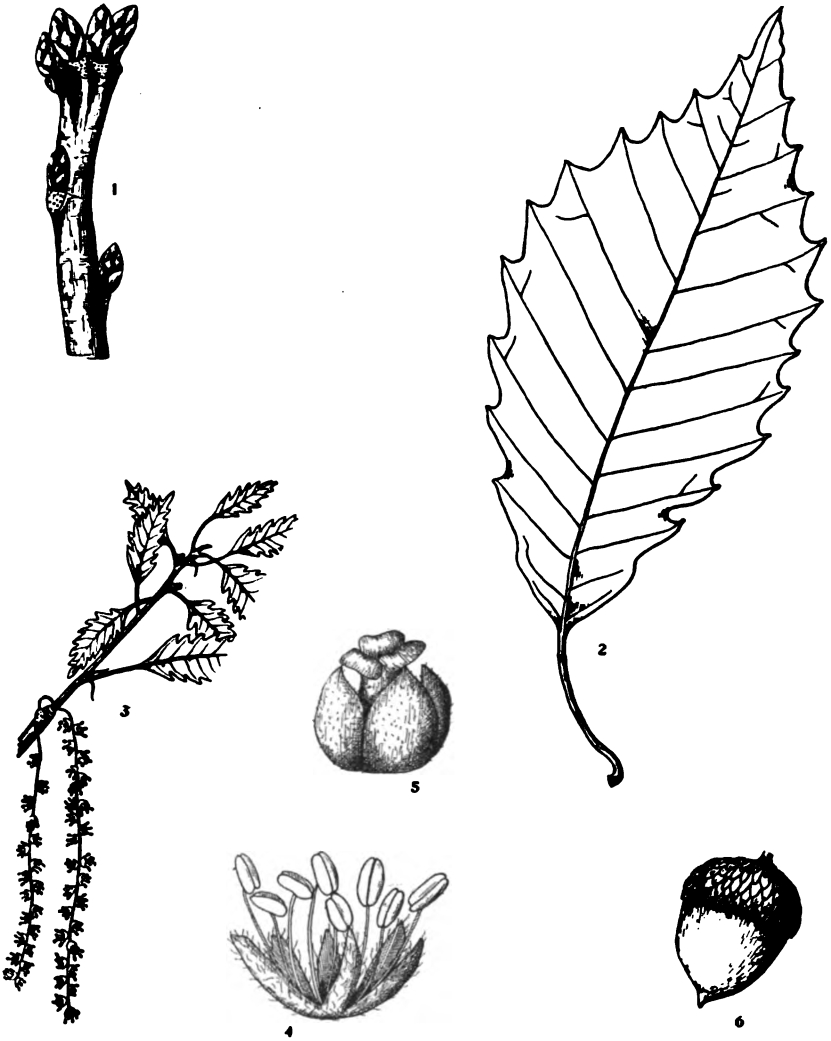
WOOD.—Heavy, hard, strong, tough, coarse-grained, light brown, with thin, indistinguishable sapwood.

DISTRIBUTION.—Frequent in the Champlain valley, especially about Lake Champlain.

HABITAT.—Prefers moist, rich soil bordering swamps and along streams.

NOTES.—In beauty and variety of grain this tree nearly equals the white oak and its wood is valuable for similar purposes. As its name suggests it grows in low, moist soil. Unfortunately the swamp oak is not found in Vermont except along the intervales of Lake Champlain and its tributaries. Here it is quite abundant and its majestic size and symmetrical, rounded top make it a conspicuous and beautiful tree. It is more easily identified than many of the oaks because of the scaly bark, the leaves downy on the lower surface and the long, downy stalks of the acorns.

Yellow Oak. Chestnut Oak



(Mich. Trees).

1. Winter twig, x 2.
2. Leaf, x ½.
3. Flowering branchlet, x ½.
4. Staminate flower, enlarged.
5. Pistillate flower, enlarged.
6. Fruit, x 1.

FAGACEAE

Yellow Oak. Chestnut Oak

Quercus muhlenbergii Engelm. [Quercus acuminata (Michx.) Houba]

HABIT.—A small to medium-sized tree 30-40 feet high, with a trunk diameter of 1-2 feet; erect, somewhat short branches form a narrow, rounded crown.

LEAVES.—Alternate, simple, 4-7 inches long, 1-4 inches broad; oblong-lanceolate to obovate; coarsely toothed; thick and firm; lustrous, yellow-green above, pale-pubescent beneath; petioles slender, about 1 inch long.

FLOWERS.—May, with the leaves; monoecious; the staminate in hairy catkins 3-4 inches long; the pistillate sessile or in short spikes, hoary-tomentose; calyx campanulate, 5-8-lobed, yellow, hairy; corolla 0; stamens 5-8, with yellow anthers; stigmas red.

FRUIT.—Autumn of first season; sessile or short-stalked acorns; cup with small scales, hoary-tomentose, inclosing one-half of the nut; nut ovoid, about ¾ inch long, light brown; kernel sweet, sometimes edible.

WINTER-BUDS.—Terminal bud ⅛ inch long, conical, acute; scales chestnut-brown, scarious on the margin.

BARK.—Twigs greenish at first, becoming gray-brown, finally gray or brown; thin, silvery gray or ash colored and flaky on the trunk.

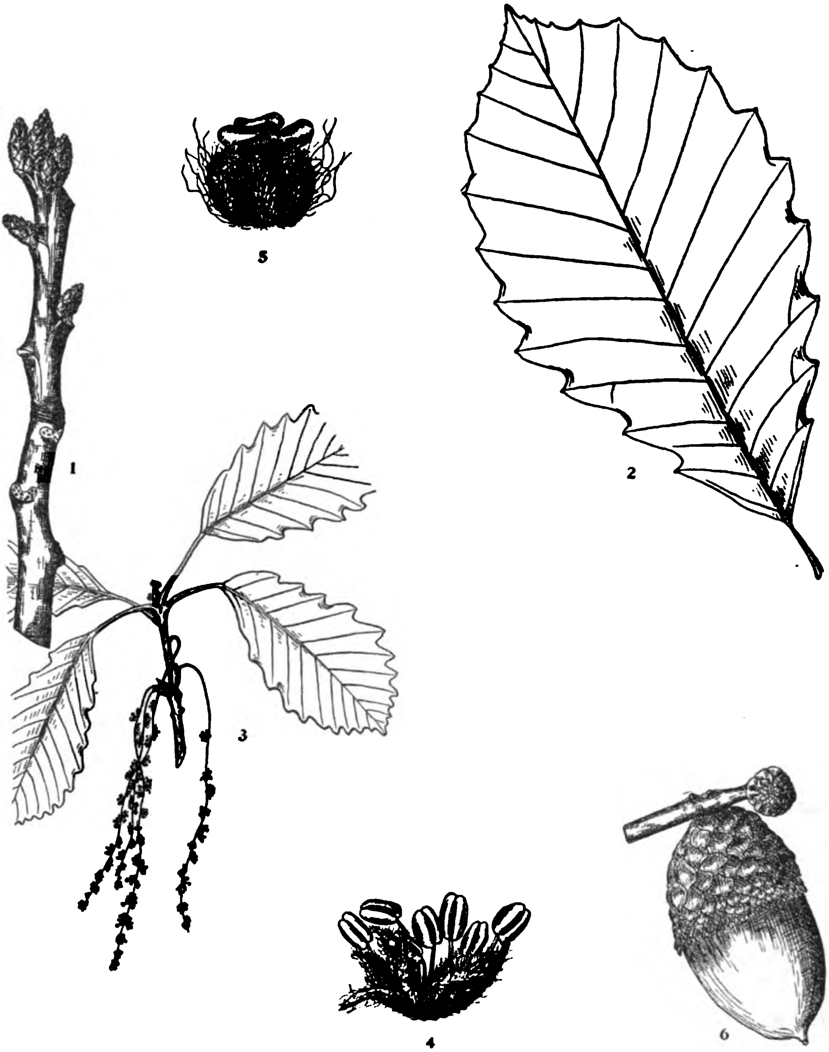
WOOD.—Heavy, very hard, strong, close-grained, durable, dark brown, with thin, pale brown sapwood.

DISTRIBUTION.—Rare; reported from Gardiner's island in Lake Champlain, Malletts Head, Ferrisburg and Colchester.

HABITAT.—Dry limestone hillsides; rocky river-banks and lake-shores.

NOTES.—This oak is a very beautiful tree and is well adapted for use in parks and on lawns on account of its handsome foliage.

Chestnut Oak



1. Winter twig, x 1.
2. Leaf, x ½.
3. Flowering branchlet, x ½.
4. Staminate flower, enlarged.
5. Pistillate flower, enlarged.
6. Fruit, x 1.

FAGACEAE

Chestnut Oak

Quercus prinus L.

HABIT.—A medium-sized tree 30-50 feet high, with a trunk diameter of 1-2 feet; usually dividing near the ground into a few large branches and forming a broad, open, rather irregular crown.

LEAVES.—Alternate, simple, 6-8 inches long and one-third to one-half as broad; lanceolate to obovate; coarsely crenate; thick and firm, almost leathery; glabrous, dark green above, paler and finely pubescent beneath; petioles ½-1 inch long.

FLOWERS.—May, with the leaves; monoecious; the staminate in hairy catkins 2-2½ inches long; the pistillate in short spikes on stout, pubescent peduncles; calyx deeply 7-9-lobed, pale yellow, pilose; corolla 0; stamens 7-9, with yellow anthers; stigmas dark red.

FRUIT.—Autumn of first season; short-stalked acorns; cup thin, deep, turbinate, inclosing one-half or less of the nut; scales small, thin-tipped, with thickened bases, hoary-pubescent; nut ovoid to oblong-ovoid, 1-1½ inches long, light brown; kernel sweet, but insipid.

WINTER-BUDS.—Terminal bud ¼-⅜ inch long, ovoid, sharp-pointed; scales light brown, slightly hairy toward the apex and on the margin.

BARK.—Twigs greenish, becoming orange and brown, with somewhat bitter taste; thick, dark red-brown to nearly black on old trunks, deeply fissured into thick, roughish ridges (a section through one of the ridges would resemble an inverted letter V).

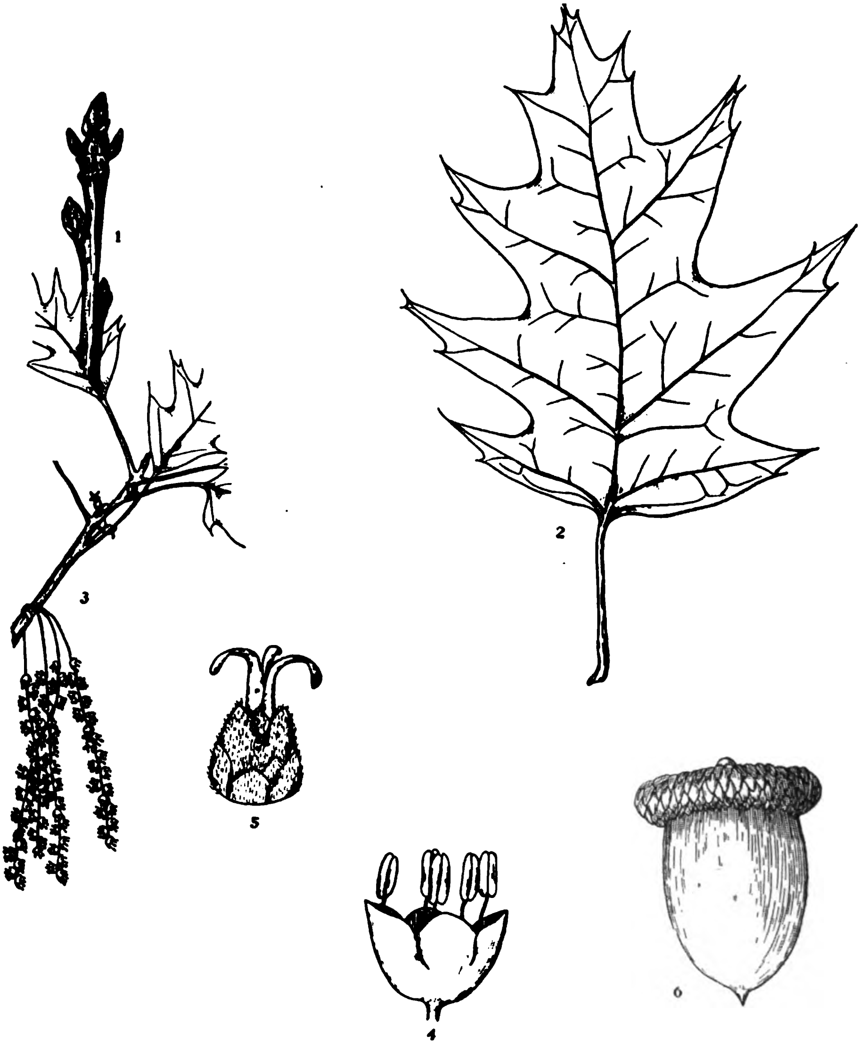
WOOD.—Heavy, hard, strong, tough, close-grained, dark brown, with thin, lighter colored sapwood.

DISTRIBUTION.—Frequent throughout the western part of Vermont from Charlotte to Pownal; abundant on Snake mountain at an altitude of 1,300 feet and on the western slopes of the Green mountains, especially in Addison county.

HABITAT.—Dry, rocky hillsides.

NOTES.—The popular name of this oak is suggested by the marked resemblance of its leaves to those of the chestnut. It is one of the common oaks from Massachusetts and New York southward, forming a large tree on rocky hillsides, often associated with the chestnut. The line of its northern distribution passes through the Champlain valley. It occurs probably also in the southeastern part of Vermont. The acorns are large, one inch or more in length. The wood is hard and tough and is used frequently for railroad ties.

Red Oak



(Mich. Trees).

1. Winter twig, x 1.
2. Leaf, x ½.
3. Flowering branchlet, x ½.
4. Staminate flower, enlarged.
5. Pistillate flower, enlarged.
6. Fruit, x 1.

FAGACEAE

Red Oak

Quercus rubra L.

HABIT.—A large tree 70-80 feet high, with a trunk diameter of 2-4 feet; forming a broad, rounded crown of a few large, wide-spreading branches and slender branchlets.

LEAVES.—Alternate, simple, 5-9 inches long, 4-6 inches broad; oval to obovate; 5-11-lobed with coarse-toothed, bristle-tipped lobes tapering from broad bases and wide, oblique, rounded sinuses; thin and firm; dull dark green above, paler beneath; petioles stout, 1-2 inches long.

FLOWERS.—May, when the leaves are half grown; monoecious; the staminate in hairy catkins 4-5 inches long; the pistillate on short, glabrous peduncles; calyx 4-5-lobed, greenish; corolla 0; stamens 4-5, with yellow anthers; stigmas long, spreading, bright green.

FRUIT.—Autumn of second season; sessile or short-stalked acorns; cup shallow, saucer-shaped, inclosing only the base of the nut; scales closely appressed, more or less glossy, puberulous, bright red-brown; nut oblong-ovoid with a broad base, about 1 inch long, red-brown; kernel white, very bitter.

WINTER-BUDS.—Terminal bud ¼ inch long, ovoid, acute, light brown, smooth.

BARK.—Twigs lustrous, green, becoming reddish, finally dark brown; young trunks smooth, gray-brown; old trunks darker, shallowly fissured into thin, firm, broad ridges; inner bark light red, not bitter. Plate V.

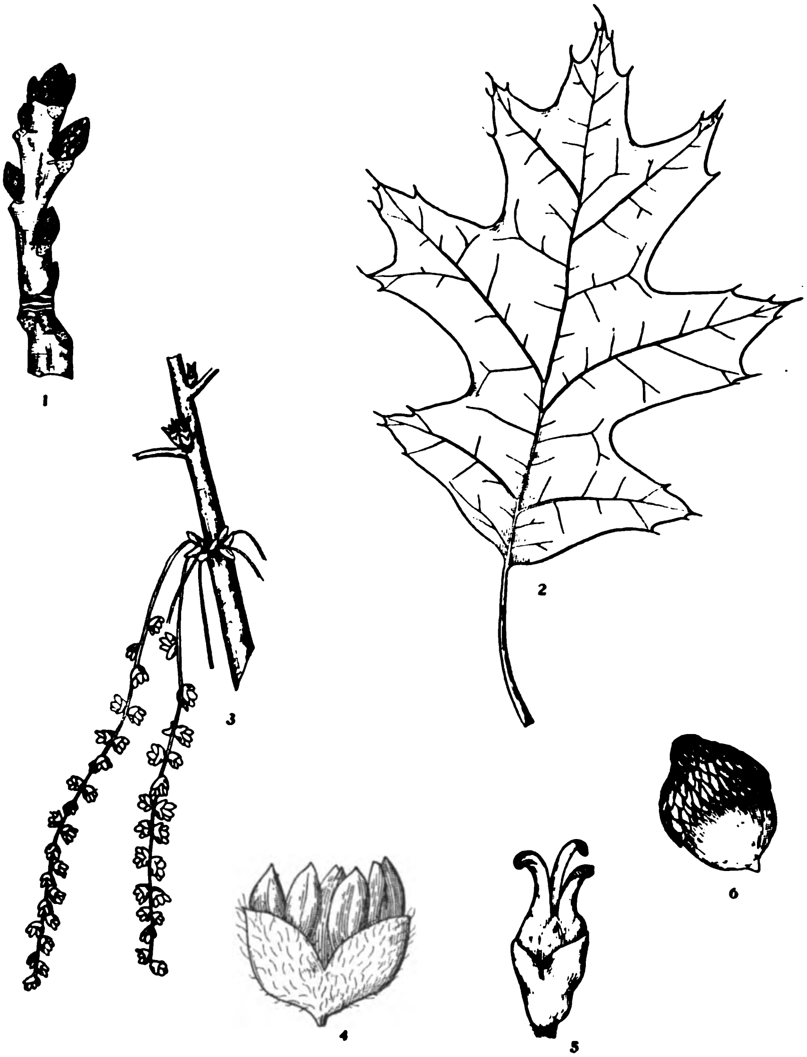
WOOD.—Heavy, hard, strong, coarse-grained, light red-brown, with thin, darker colored sapwood. Page 230.

DISTRIBUTION.—Common throughout Vermont at altitudes below 1,000 feet.

HABITAT.—Grows well in all well-drained soils; rich and poor soil.

NOTES.—The red oak is the most northern of all the oaks, ranging from Nova Scotia to Tennessee. It is distributed generally through the Champlain and lower Connecticut valleys where it is the most common oak. It is less common in the northern part of the Connecticut valley. The flowers appear in May but the sessile, shallow-cupped acorns do not ripen until the second autumn. The wood is lighter in weight and more brittle than that of the white oak but when quartered shows a beautiful grain and is used for furniture. It is valued also for bridge posts where there is to be exposure to water. The wood dries out slowly and is inferior as fuel.

Quercitron. Yellow-barked Oak. Black Oak



(Mich. Trees).

1. Winter twig, x 1.
2. Leaf, x ½.
3. Flowering branchlet, x ½.
4. Staminate flower, enlarged.
5. Pistillate flower, enlarged.
6. Fruit, x 1.

FAGACEAE

Quercitron. Yellow-barked Oak. Black Oak

Quercus velutina Lam.

HABIT.—A medium-sized tree 50-60 feet high and 1-3 feet in trunk diameter; slender branches and stout branchlets form a wide-spreading, rounded crown.

LEAVES.—Alternate, simple, 5-10 inches long, 3-8 inches broad; ovate to oblong; usually 7-lobed, some with shallow sinuses and broad, rounded, mucronate lobes, others with wide, rounded sinuses extending half-way to the midrib or farther and narrow-oblong or triangular, bristle-tipped lobes, the lobes more or less coarse-toothed, each tooth bristle-tipped; thick and leathery; dark green and shining above, pale and more or less pubescent beneath; petioles stout, yellow, 3-6 inches long.

FLOWERS.—May, when the leaves are half grown; monoecious; the staminate in pubescent catkins 4-6 inches long; the pistillate reddish, on short, tomentose peduncles; calyx acutely 3-4-lobed, reddish, hairy; corolla 0; stamens usually 4-5, with acute, yellow anthers; stigmas 3, divergent, red.

FRUIT.—Autumn of second season; sessile or short-stalked acorns; cup cup-shaped or turbinate, inclosing about one-half of the nut; scales thin, light brown, hoary; nut ovoid, ½-¾ inch long, red-brown, often pubescent; kernel yellow, bitter.

WINTER-BUDS.—Terminal bud ¼ inch long, ovoid to conical, obtuse, strongly angled, hoary-tomentose.

BARK.—Twigs at first scurfy-pubescent, later glabrous, red-brown, finally mottled gray; thick and nearly black on old trunks, deeply furrowed and scaly; inner bark thick, yellow, very bitter. Plate V.

WOOD.—Heavy, hard, strong, coarse-grained, bright red-brown, with thin, paler sapwood.

DISTRIBUTION.—Frequent in western Vermont and in the Connecticut valley as far north as Bellows Falls.

HABITAT.—Dry, light soil; poor soils.

NOTES.—The quercitron or yellow-barked oak is a southern species which reaches its northern limit in Vermont. It is not uncommon in light, dry soils in the Champlain valley and it occurs also in the southern part of the Connecticut valley. The two common and apparently incompatible names, yellow oak and black oak, arise from the diverse colors of the inner bark and the outer bark. The former, which is used in tanning, is yellow, while the later is very dark. The leaves are rather large, dark, shiny green with yellowish petioles.

THE ELMS

We are fortunate in having in Vermont all of the elms of the eastern United States except one small southern species. The tiny greenish flowers have no petals, but gracefully fringe the bare trees with their long slender stamens in early spring before the appearance of the leaves. The fruits are supplied with a disk-like membranous wing. The leaves of all the elms have a peculiar oblique base, full and rounded upon one side, sharply wedge-shaped on the other.

Introduced species.—The English elm occasionally has been planted as a shade tree, although for such purposes it is less stately than our common white elm. Two European varieties have been more used for ornamental plantings, though each of them is curious rather than ornamental. These are the corky variety of the English elm, and the Camperdown or weeping elm, which is a variety of the Scotch elm. The young branches of the former are covered with conspicuous corky outgrowths, similar to those of the native cork elm, but more strongly developed. The American cork elm is distinguished from the English elm by its more downy bud-scales and by the production of flowers in elongated clusters (racemes), whereas those of the English elm are in close clusters. Other differences will be detected readily by those having occasion to compare the two trees. The weeping elm usually is reverse-grafted on an upright stock, leading to a peculiar umbrella-like development.

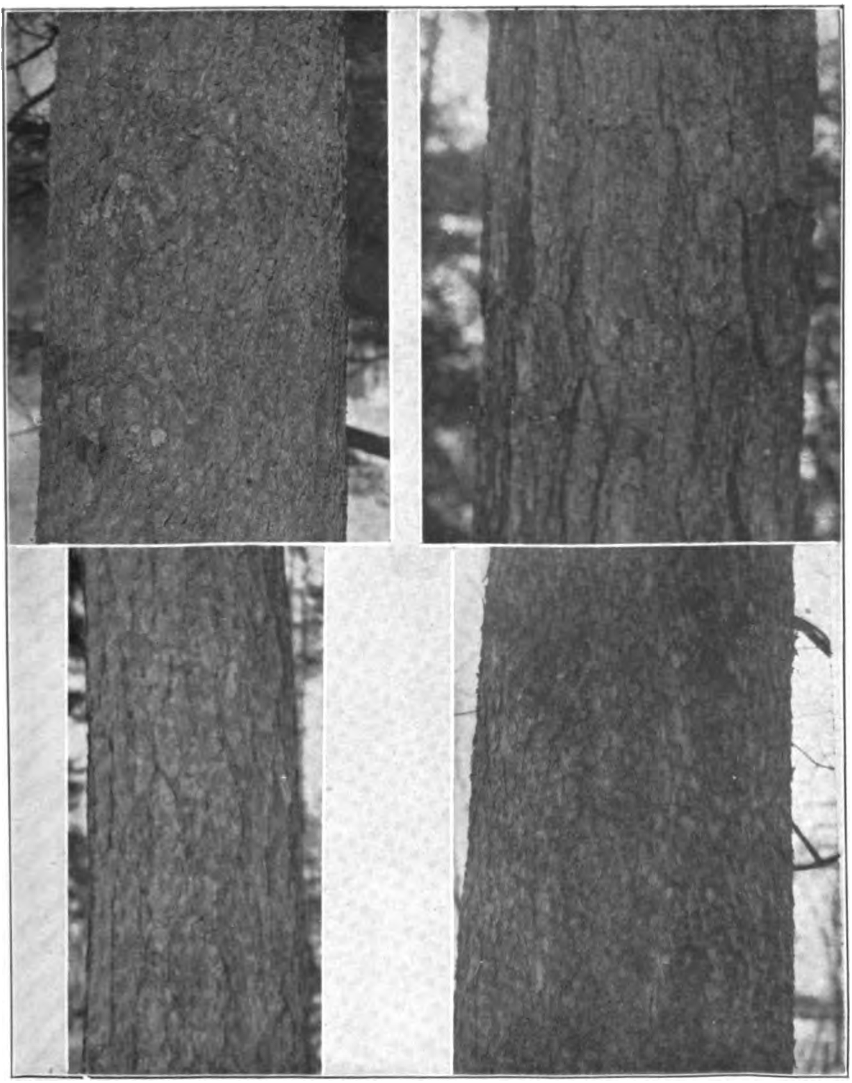


Plate I.

White Pine — Pitch Pine

Red Pine — Tamarack

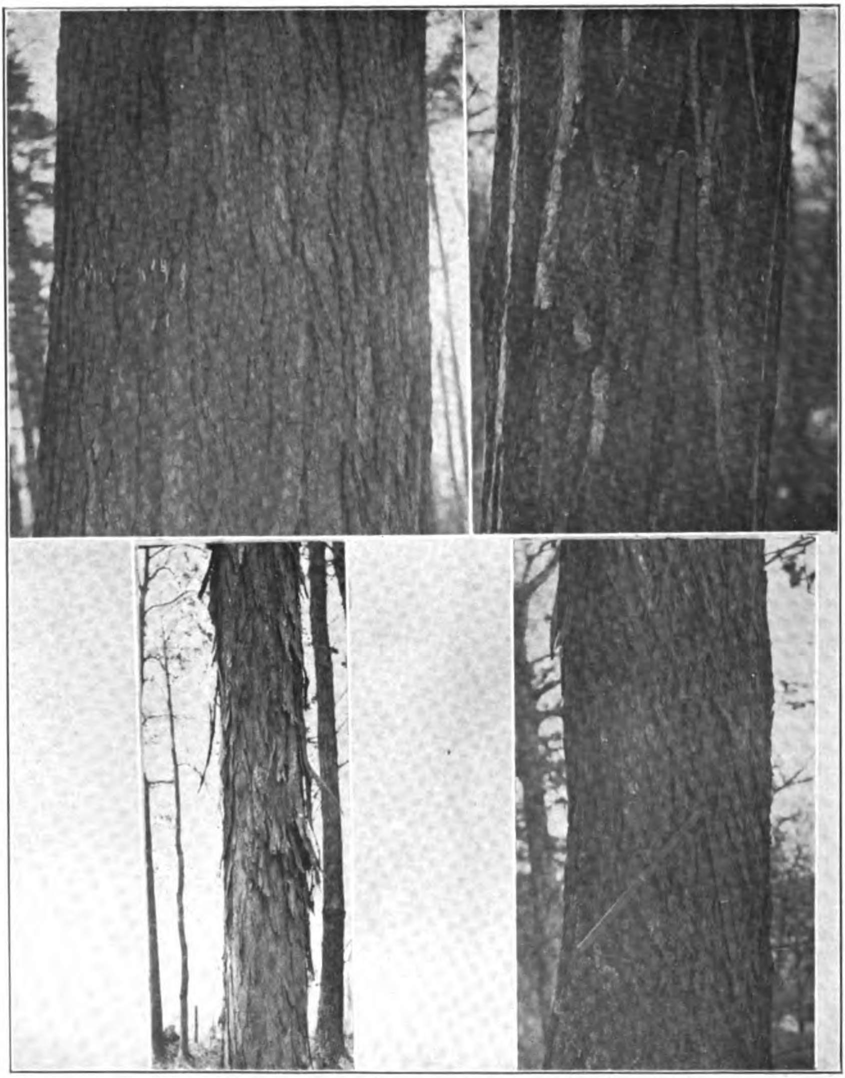


PLATE II.

Hemlock	Butternut
Shellbark Hickory	Pignut

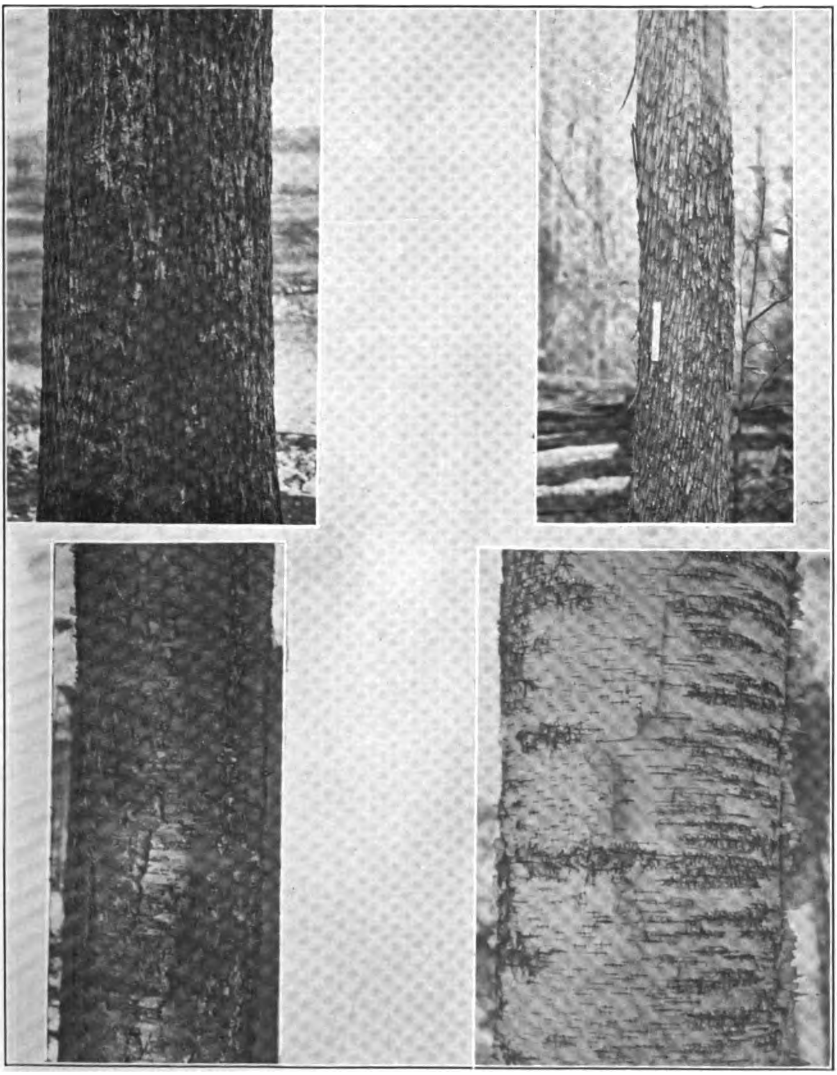


PLATE III.

Bitternut **Hornbeam**

Yellow Birch **White Birch**

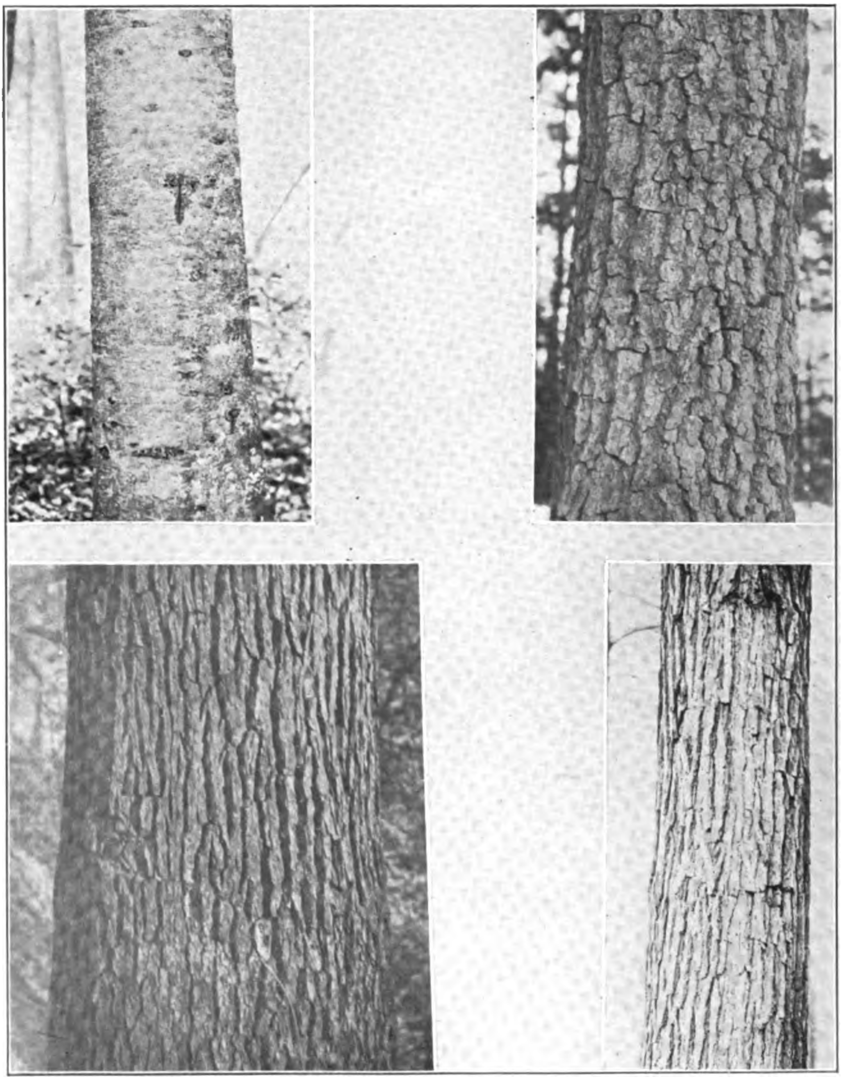


Plate IV.

Beech — Chestnut

White Oak — Swamp White Oak

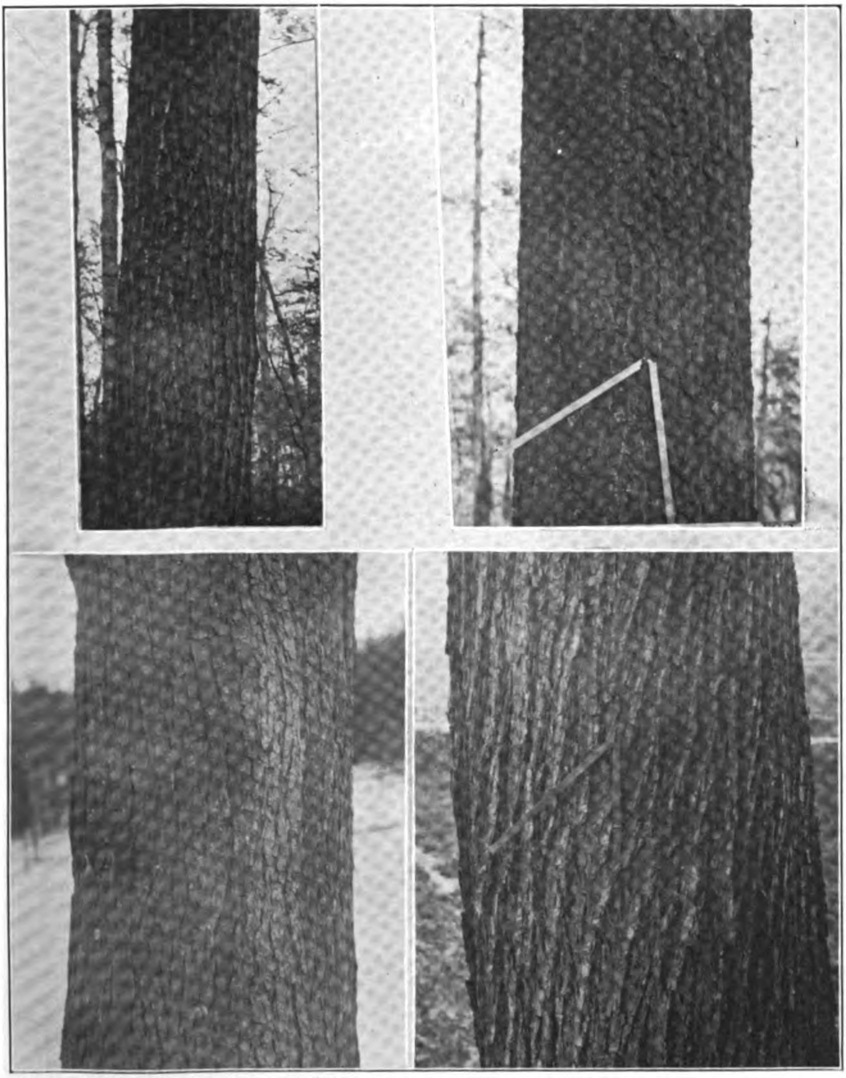


Plate V.

Red Oak **Black Oak**

Slippery Elm **American Elm**

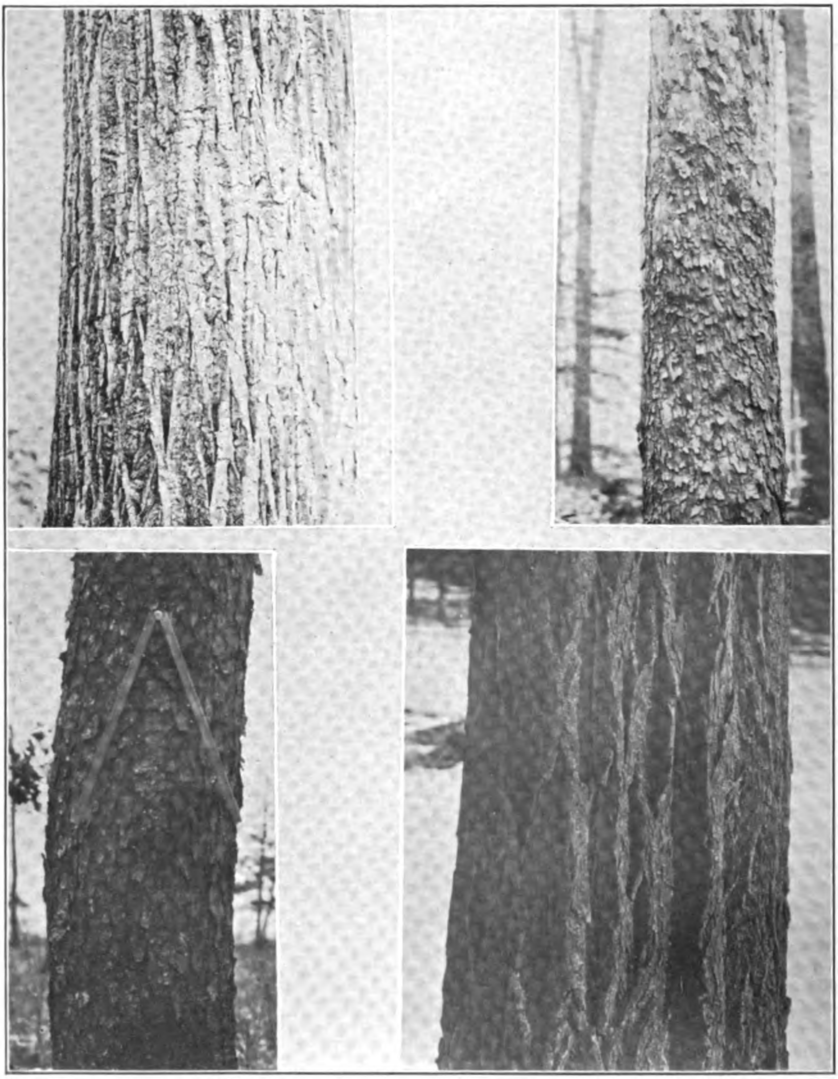


PLATE VI.

Tulip Poplar

Sycamore

Black Cherry

Black Locust

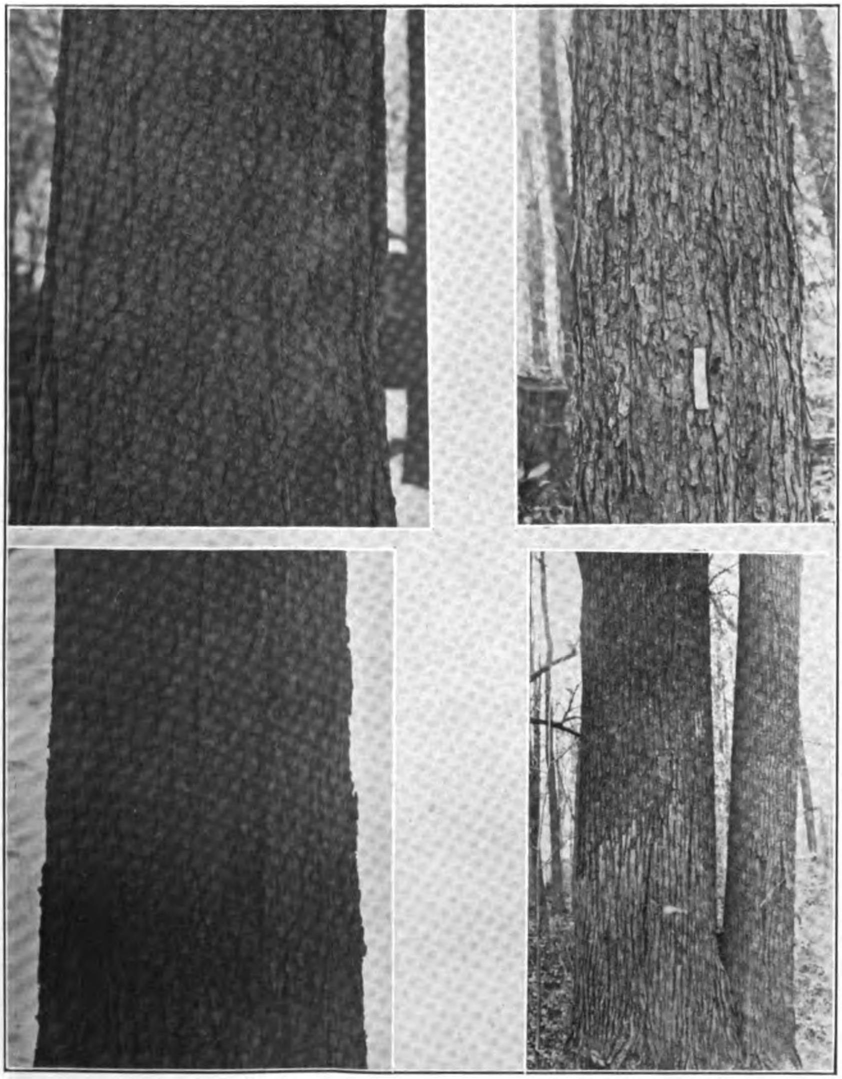


PLATE VII.

Sugar Maple

Red Maple

Silver Maple

Basswood

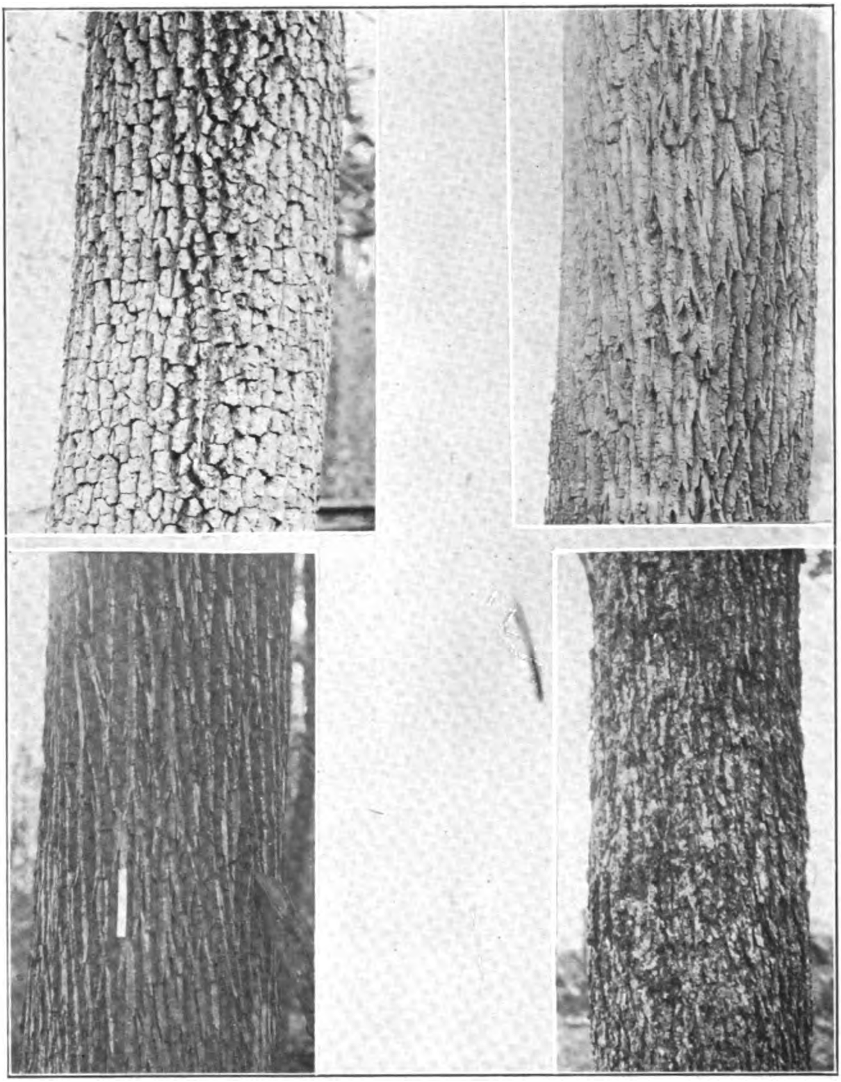


PLATE VIII.

Black Gum

White Ash

Red Ash

Black Ash

SUMMER KEY TO THE SPECIES OF ULMUS

a. Leaves essentially smooth on both sides; branches often with corky, wing-like ridges; lowermost branches usually short and strongly drooping; main trunk usually continuous into the crown without dividing, giving to the tree a narrow-oblong outline, **U. racemosa,** p. 135.

aa. Leaves usually rough on one or on both sides; branches without corky ridges; lowermost branches not short, not strongly drooping; main trunk usually dividing into several large limbs, giving to the tree a more or less vase-shaped outline.

- *b.* Leaves usually rough above, but smooth beneath, with petioles glabrous; bark of trunk gray, deeply fissured into broad, scaly ridges; inner bark not mucilaginous....**U. americana,** p. 133.
- *bb.* Leaves usually rough both sides, with petioles hairy; bark of trunk dark red-brown, shallowly fissured into large, loose plates; inner bark mucilaginous ....**U. fulva,** p. 131.

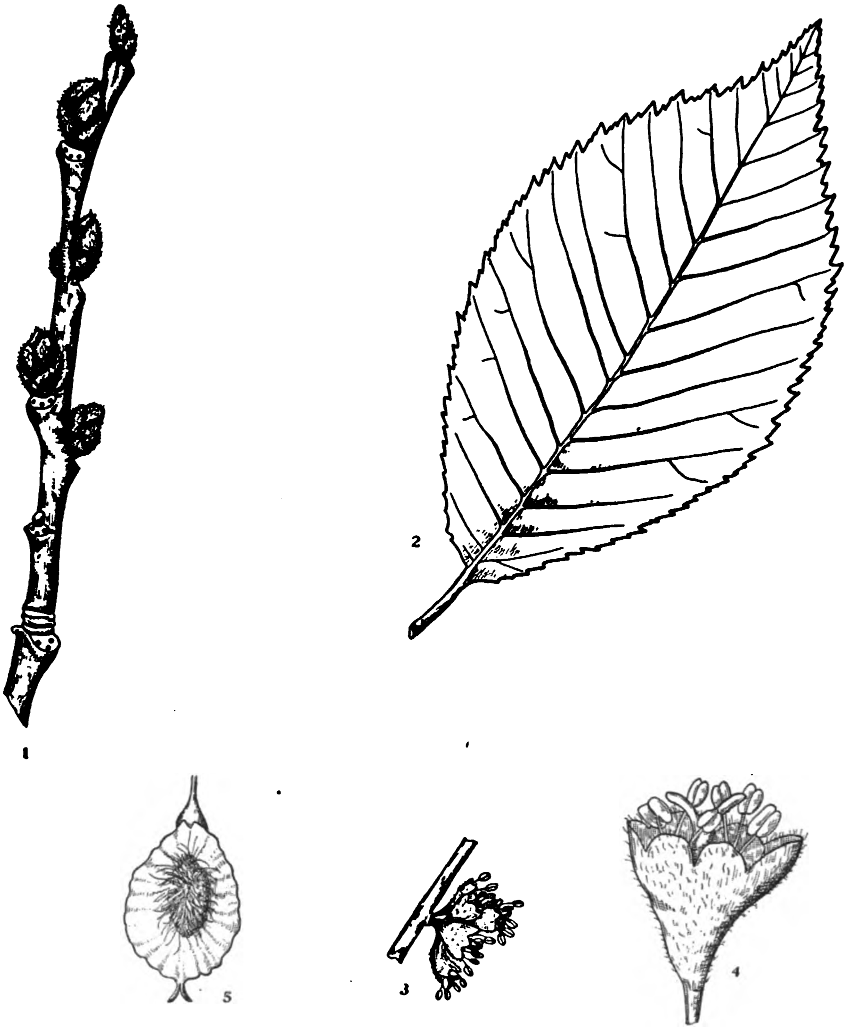
WINTER KEY TO THE SPECIES OF ULMUS

a. Buds conspicuously rusty-tomentose; twigs more or less pubescent; inner bark very mucilaginous when chewed....**U. fulva,** p. 131.

aa. Buds not conspicuously rusty-tomentose; twigs glabrous; inner bark not mucilaginous.

- *b.* Bundle-scars usually 3; buds ⅛ inch long, glabrous; twigs without corky ridges; outline of tree vase-shaped, **U. americana,** p. 133.
- *bb.* Bundle-scars usually 4-6 in a curved line; buds ¼ inch long, somewhat pilose; twigs often with corky ridges; outline of tree narrow-oblong ....**U. racemosa,** p. 135.

Slippery Elm. Red Elm



(Mich. Trees).

1. Winter twig, x 2.
2. Leaf, x 1.
3. Flowering branchlet, x 1.
4. Perfect flower, enlarged.
5. Fruit, x 1.

URTICACEAE

Slippery Elm. Red Elm

Ulmus fulva Michx. [Ulmus pubescens Walt.]

HABIT.—A medium-sized tree 40-60 feet high, with a short trunk 1-2 feet in diameter; spreading branches form a broad, open, flat-topped crown.

LEAVES.—Alternate, simple, 4-7 inches long, about one-half as broad; ovate-oblong; coarsely doubly serrate; thick and firm; dark green and rough above, paler and somewhat rough beneath; petioles short, stout, hairy.

FLOWERS.—April, before the leaves; mostly perfect; borne on short pedicels in crowded fascicles; calyx campanulate, 5-9-lobed, green, hairy; corolla 0; stamens 5-9, with dark red anthers; stigmas 2, reddish purple.

FRUIT.—May; semi-orbicular, 1-seeded samaras, short-stalked in dense clusters; seed cavity brown-tomentose; wings smooth, nearly ¾ inch long.

WINTER-BUDS.—Terminal bud absent; lateral buds ovoid, obtuse, dark brown, rusty-tomentose, ¼ inch long.

BARK.—Twigs at first bright green and pubescent, becoming light to dark brown or grayish; thick on old trunks, dark red-brown, shallowly fissured into large, loose plates; inner bark mucilaginous. Plate V.

WOOD.—Heavy, hard, strong, very close-grained, durable, easy to split while green, dark red-brown, with thin, lighter colored sapwood.

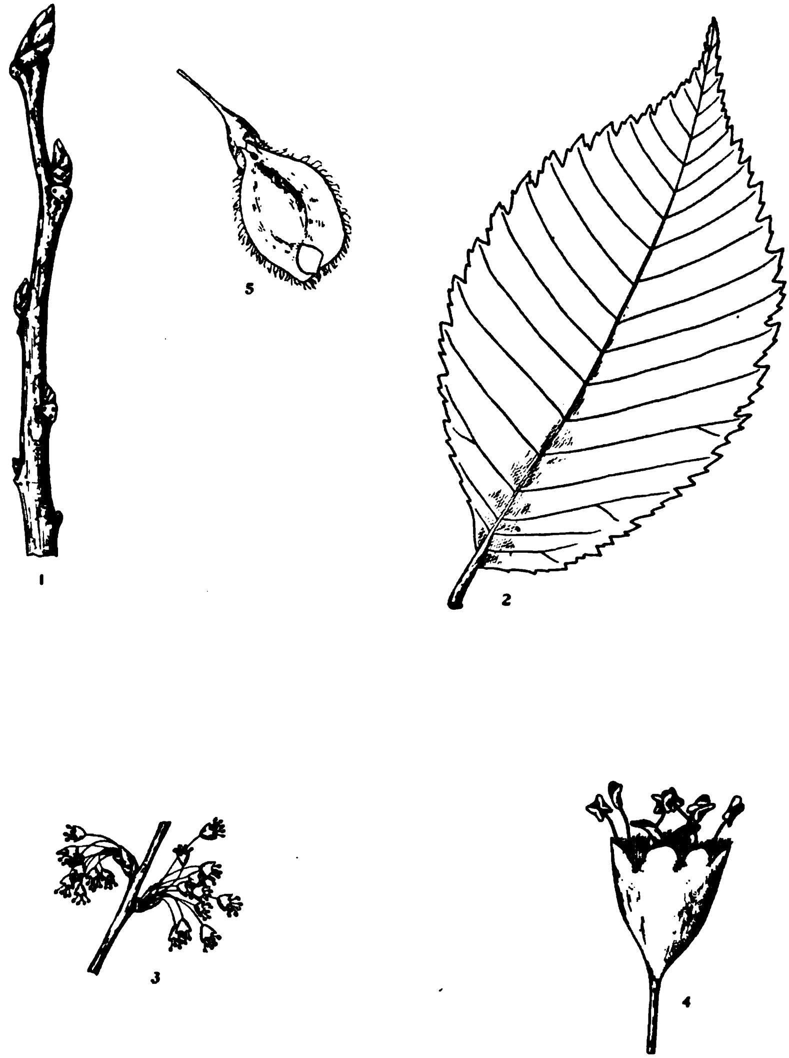
DISTRIBUTION.—Occasional throughout Vermont.

HABITAT.—Rich, rocky woods.

NOTES.—The slippery elm is not uncommon in Vermont. The scattering trees of this species, however, usually are passed unnoticed because it resembles the American elm so closely that it is not easy to distinguish the two by general appearance. The stringy mucilaginous bark of the slippery elm always is a sure means of recognition.

Other means of distinguishing it are found in its circular fruits, which appear in May; these have smooth margins, whereas those of both the other species are fringed with delicate hairs. The leaves are large, rough above and soft-downy beneath. But the surest and simplest test is the "slippery" bark. This has well-known medicinal properties which give it a recognized value in the drug trade. The slippery elm is usually found on rocky ridges and hillsides.

American Elm. White Elm



(Mich. Trees).

1. Winter twig, x 2.
2. Leaf, x ½.
3. Flowering branchlet, x ½.
4. Flower, enlarged.
5. Fruit, x 2.

URTICACEAE

American Elm. White Elm

Ulmus americana L.

HABIT.—A tree 75-100 feet high, with a trunk diameter of 2-6 feet; commonly dividing 20-30 feet above the ground into a few large branches which rise upward and outward to form a vase-shaped outline.

LEAVES.—Alternate, simple, 4-6 inches long, one-half as broad; obovate-oblong to oval; coarsely doubly serrate; thick and firm; dark green and rough above, pale and pubescent or glabrous beneath; petioles short and stout.

FLOWERS.—April, before the leaves; mostly perfect; small, brown to red; borne on slender pedicels in loose fascicles; calyx campanulate, 5-9-lobed; corolla 0; stamens 4-9, with bright red anthers; ovary 2-celled; styles 2, green.

FRUIT.—May; ovate, 1-seeded samaras, smooth both sides, hairy on the margin, ½ inch long, long-stemmed in crowded clusters.

WINTER-BUDS.—Terminal bud absent; lateral buds ovoid, acute, flattened, glabrous, brown, ⅛ inch long.

BARK.—Twigs at first light green and downy, becoming glabrous, red-brown, finally ash-gray; on old trunks thick, ash-gray, deeply fissured into broad, scaly ridges. Plate V.

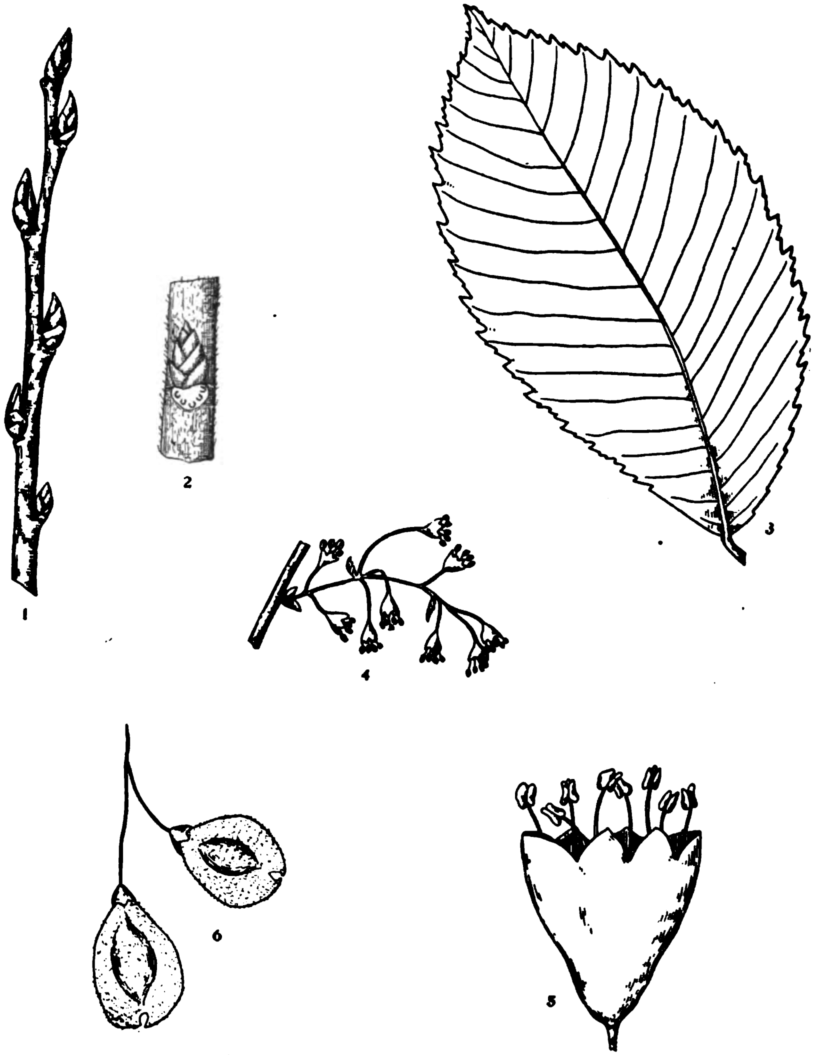
WOOD.—Heavy, hard, strong, tough, difficult to split, coarse-grained, light brown, with thick, lighter colored sapwood. Page 225.

DISTRIBUTION.—Common throughout Vermont.

HABITAT.—Prefers deep, rich, moist loam; bottom-lands; stream-banks.

NOTES.—Of all the native trees none has done more than the white elm to beautify the streets of our cities and villages or to grace our country hillsides and meadows. The spreading vase-shaped head is its typical form, but perfect trees are found only where there has been a free development of the branches from the sapling age. Even when developing freely, however, the trees vary markedly in form. Some may be found which are very strict and upright others which are straggling and strongly weeping. The bark characters also vary much in different trees. Numerous clusters of slender, drooping flowers open before the leaves in early May, giving the tree a delicate feathery appearance. The seeds mature and fall before the leaves are grown fully. The wood is very tough and fibrous, making it useful for ox yokes, wagon bolsters, hubs of wheels and similar purposes where there is special cross-strain.

Cork Elm



(Mich. Trees).

1. Winter twig, x 1.
2. Portion of twig, enlarged.
3. Leaf, x 1.
4. Flowering branchlet, x 1.
5. Flower, enlarged.
6. Fruit, x 1.

URTICACEAE

Cork Elm

Ulmus racemosa Thomas [Ulmus Thomasi Sarg.]

HABIT.—A large tree reaching a height of 50-75 feet and a trunk diameter of 2-3 feet; strongly drooping lateral and lower branches form a narrow, oblong crown.

LEAVES.—Alternate, simple, 3-6 inches long, one-half as broad; obovate to oblong-oval, more or less dished; coarsely doubly serrate; thick and firm; lustrous, dark green above, pale-pubescent beneath; petioles pubescent, ¼ inch long.

FLOWERS.—April-May, before the leaves; mostly perfect; greenish; borne on slender, drooping pedicels in loose racemes; calyx campanulate, 7-8-lobed; corolla 0; stamens 7-8, with purple anthers; ovary hairy, 2-styled.

FRUIT.—May-June; ovate, 1-seeded samaras, pubescent all over, ½ inch long.

WINTER-BUDS.—Terminal bud absent; lateral buds ovoid, acute, brown, pilose, ¼ inch long.

BARK.—Twigs at first light brown and pubescent, becoming lustrous, red-brown, finally gray-brown with corky, wing-like ridges; thick and grayish on the trunk, with wide fissures separating broad, flat, scaly ridges.

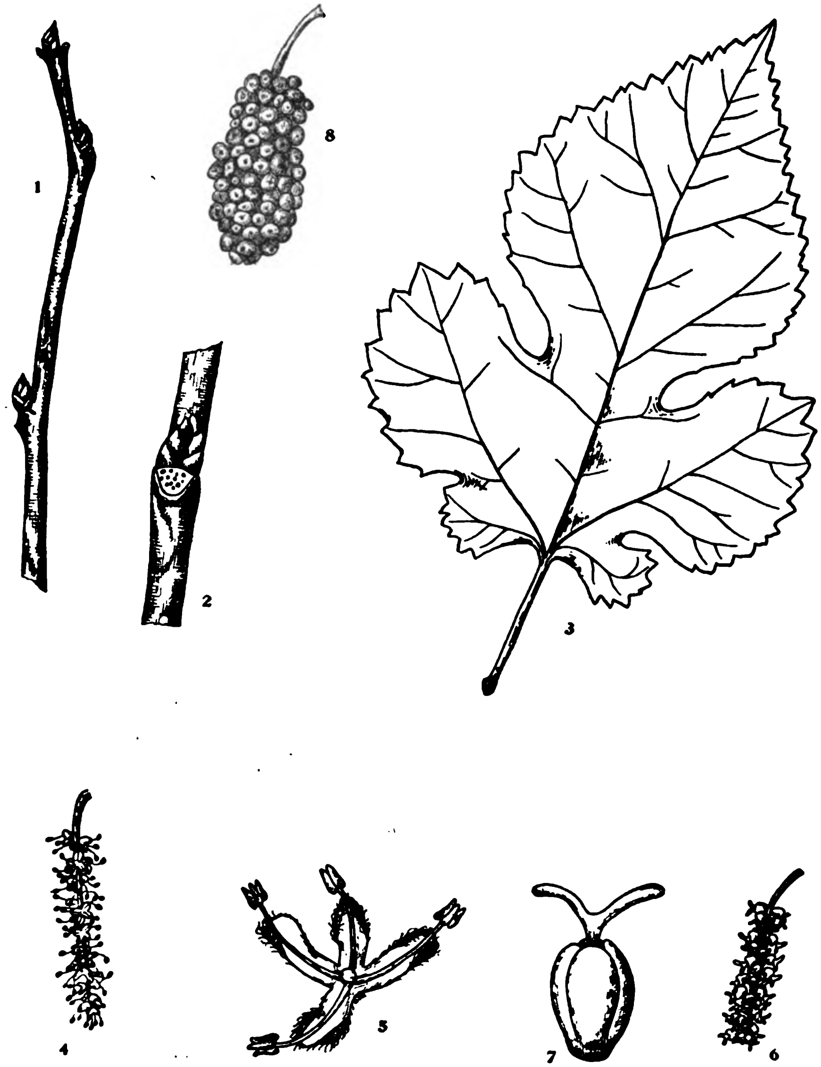
WOOD.—Heavy, very strong and tough, close-grained, light red-brown, with thick, lighter colored sapwood.

DISTRIBUTION.—Western Vermont, west of the Green mountains, becoming relatively more abundant in the Champlain valley; rare.

HABITAT.—River-banks and limestone soils.

NOTES.—The cork elm is a more valuable timber tree but it is found only in the limestone soils of western Vermont, and there but rarely. Its peculiarity is a growth of corky ridges which sometimes project for half an inch or more from all sides of the younger branches. The leaves resemble those of the white elm but are more conspicuously downy upon the under side along the midribs. The bud-scales are also downy and the young branchlets somewhat so, whereas those of the white elm are smooth. The flowers are borne in open branching clusters, or racemes, and this characteristic gives the Latin name to the species. The fruit matures when the leaves are half grown.

Red Mulberry



(Mich. Trees).

1. Winter twig, x 1.
2. Portion of twig, enlarged.
3. Leaf, x 1.
4. Spike of staminate flowers, x 1.
5. Staminate flower, enlarged.
6. Spike of pistillate flowers, x 1.
7. Pistillate flower, enlarged.
8. Fruit, x 1.

ACERACEAE

Red Maple. Swamp Maple

Acer rubrum L.

HABIT.—A medium-sized tree 40-50 feet high, occasionally in swamps 60-75 feet; trunks 1-3 feet in diameter; upright branches, which form a low, rather narrow, rounded crown.

LEAVES.—Opposite, simple, 3-4 inches long and nearly as broad; 3-5-lobed by broad, acute sinuses, the lobes irregularly doubly serrate or toothed; glabrous, green above, whitish and generally glabrous beneath, turning bright scarlet in autumn; petioles long, slender.

FLOWERS.—April-May, before the leaves; polygamo-monoecious or dioecious; in few-flowered fascicles on shoots of the previous year, the pistillate red, the staminate orange; sepals 4-5; petals 4-5; stamens 5-8; ovary smooth.

FRUIT.—May-June, germinating immediately after reaching the ground; samaras small, on drooping pedicels 2-4 inches long; wings about 1 inch long, diverging at about a right angle.

WINTER-BUDS.—Dark red, blunt; terminal bud about ⅛ inch long, with bud-scales rounded at the apex; flower-buds clustered on side spurs.

BARK.—Twigs bright red, lustrous, becoming smooth and light gray on the branches; old trunks dark gray, ridged, separating into plate-like scales. Plate VII.

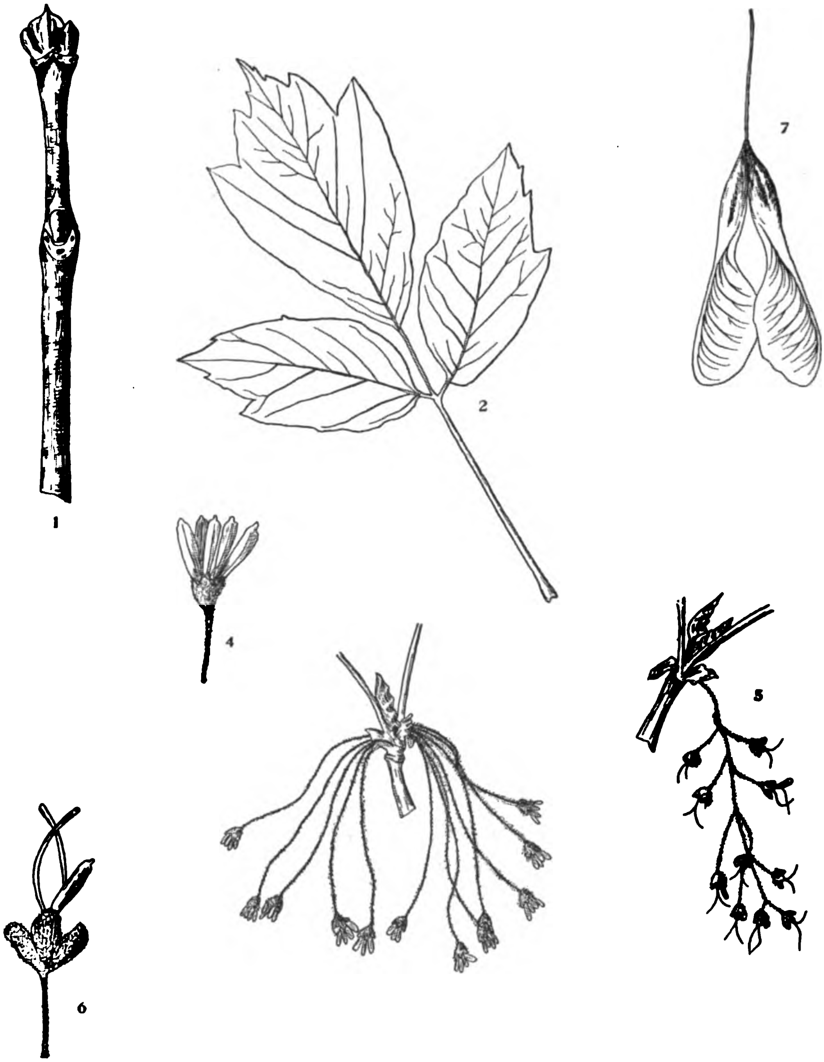
WOOD.—Heavy, close-grained, not strong, light brown, with thick, lighter colored sapwood.

DISTRIBUTION.—Common throughout Vermont.

HABITAT.—Prefers swamp-lands or banks of streams; moist woods.

NOTES.—The scarlet flowers of this maple give us the brightest spring welcome from the trees. When the red maple is a blaze of color and the other trees are still bare and brown, it is conspicuous and unmistakable, and in autumn the rich coloring of its leaves makes it conspicuous again. The leaves of the silver maple turn yellow and those of the sugar maple yellow or red, but not the crimson or deep red of the red maple. It is distinguished from the sugar maple by its smoother, dark gray bark and by the deeper acute incisions of the leaves although they are subject to much variation. The fruit is about one inch long and like that of silver maple falls in early summer. This tree, common throughout the eastern United States, is very generally distributed in Vermont.

Box Elder



(Mich. Trees).

1. Winter twig, x 1.
2. Leaf, x ½.
3. Staminate flowering branchlet, x ½.
4. Staminate flower, enlarged.
5. Pistillate flowering branchlet, x ½.
6. Pistillate flower, enlarged.
7. Fruit, x 1.

ACERACEAE

Box Elder

Acer negundo L. [Negundo aceroides Moench.]

HABIT.—A sturdy little tree 30-40 feet high, with a trunk diameter of 1-2 feet. Trunk often divides near the ground into several stout, wide-spreading branches, forming a broad, unsymmetrical, open crown.

LEAVES.—Opposite, pinnately compound. Leaflets 3-5 in number, 2-4 inches long, 1½-2½ inches broad; ovate or oval; nearly entire, irregularly and remotely coarse-toothed above the middle, or sometimes 3-lobed (often giving the leaflet a jagged outline); apex acute, base variable; glabrous or somewhat pubescent at maturity, with prominent veins. Petioles slender, 2-3 inches long, the enlarged base leaving prominent crescent-shaped scars partly surrounding the winter-buds.

FLOWERS.—April-May, before or with the leaves; dioecious; small, yellow-green; the staminate in clusters on long, thread-like, hairy pedicels; the pistillate in narrow, drooping racemes; calyx hairy, 5-lobed; corolla 0; stamens 4-6; ovary pubescent.

FRUIT.—Early summer, but hanging until late autumn or early spring; narrow, flat, winged samaras, in pairs, clustered in drooping, racemose clusters.

WINTER-BUDS.—Terminal bud ⅛-¼ inch long, acute, inclosed in two dull red scales, often hoary or minutely pubescent; lateral buds obtuse, appressed.

BARK.—Twigs greenish to purple, glaucous; trunk pale gray or light brown, deeply cleft into broad ridges.

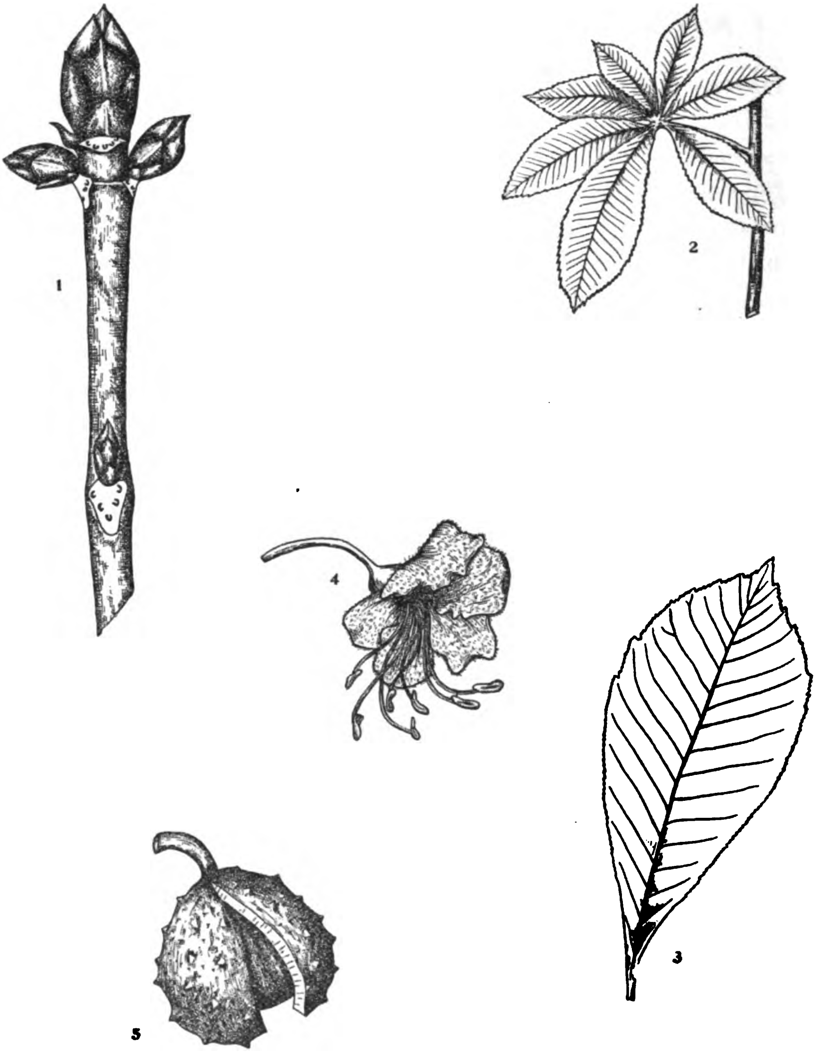
WOOD.—Light, soft, close-grained, weak, creamy white, with thick, hardly distinguishable sapwood.

DISTRIBUTION.—From the Winooski river southward, in some places locally abundant; occurs sparingly along streams in the Champlain valley.

HABITAT.—Banks of streams and borders of swamps. Prefers deep, moist soil.

NOTES.—The box elder accommodates itself to almost any situation. It is easily transplanted and grows rapidly. For these reasons it is sometimes planted for shade and ornament, but it is not a desirable tree for this purpose.

Common Horse-chestnut



(Mich. Trees).

1. Winter twig, x ¾.
2. Leaf, x ⅙.
3. Leaflet, x ½.
4. Flower, x 1.
5. Fruit, x ½.

SAPINDACEAE

Common Horse-chestnut

Aesculus hippocastanum L.

HABIT.—A handsome tree, with a height of 40-60 feet and a trunk diameter of 1-2 feet, forming a broad, conical crown. The regularly occurring branches ascend from the trunk at first, gradually bend downwards as they lengthen, and end in a thick, upturning spray.

LEAVES.—Opposite, digitately compound. Leaflets usually 7, rarely 5, 5-7 inches long, 1½-2½ inches broad; obovate, wedge-shaped at the base; irregularly and bluntly serrate; thick; rough, dark green above, paler beneath, turning a rusty yellow in autumn. Petioles long, grooved, swollen at the base.

FLOWERS.—May-June, after the leaves; polygamo-monoecious; large, whitish, in showy, upright, terminal thyrses 8-12 inches long; pedicels jointed, 4-6-flowered; calyx campanulate, 5-lobed; petals 5, white, spotted with yellow and red, clawed; stamens 7, thread-like, longer than the petals.

FRUIT.—October; a leathery, globular capsule about 2 inches in diameter, roughened with short spines; containing 1-3 large, smooth, lustrous, brown nuts, marked by large, pale scars.

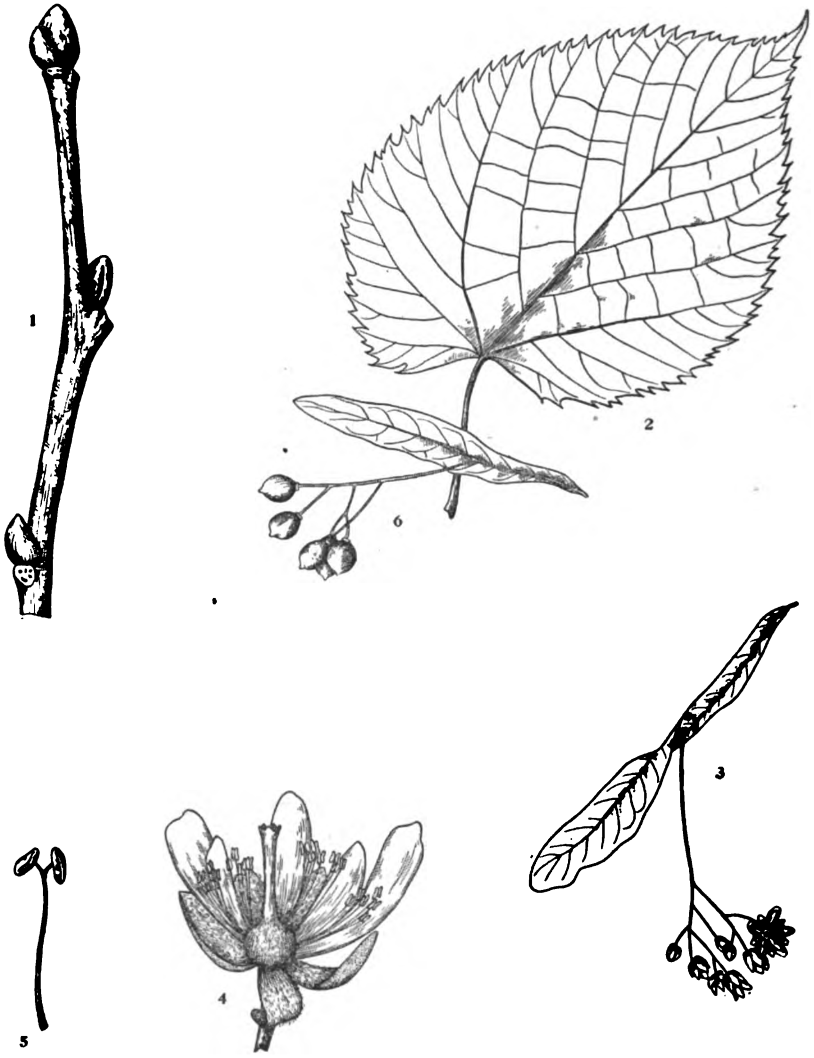
WINTER-BUDS.—Terminal buds 1-1½ inches long, acute, brownish, covered with glistening, resinous gum; inner scales yellowish, becoming 1½-2 inches long in spring, remaining until the leaves are nearly half grown.

BARK.—Twigs smooth, red-brown; trunk dark brown and broken into thin plates by shallow fissures; rich in tannin, bitter.

WOOD.—Light, soft, close-grained, weak, whitish, with thin, light brown sapwood.

NOTES.—The horse-chestnut is a native of Greece, but it is extensively cultivated throughout Europe and America, where it is favorite shade tree. A double-flowered variety, *Aesculus hippocastanum, v. flòre plèno,* which bears no fruit is a common garden form.

Basswood



(Mich. Trees).

1. Winter twig, x 1.
2. Leaf, x ½.
3. Cyme of flowers, with its bract, x ½.
4. Flower, with two petals, petaloid scales and stamens removed, enlarged.
5. Stamen, enlarged.
6. Fruit, x ½.

TILIACEAE

Basswood

Tilia americana L.

HABIT.—A tree usually 60-70 feet high, with a tall, straight trunk 2-4 feet in diameter; numerous slender branches form a dense, ovoid or rounded crown.

LEAVES.—Alternate, simple, 5-6 inches long, 3-4 inches broad; obliquely heart-shaped; coarsely serrate; thick and firm; glabrous, dull dark green above, paler beneath; petioles slender, 1-2 inches long.

FLOWERS.—June-July, after the leaves; perfect, regular; yellowish white, downy, fragrant; borne on slender pedicels in loose, drooping cymes, the peduncle attached for half its length to a narrow, oblong, yellowish bract; sepals 5, downy; petals 5, creamy white; stamens numerous, in 5 clusters; ovary 5-celled; stigma 5-lobed.

FRUIT.—October; globose, nut-like, woody, gray, tomentose, about the size of peas.

WINTER-BUDS.—Terminal bud absent; lateral buds ovoid, acute, often lopsided, smooth, dark red, ¼ inch long.

BARK.—Twigs smooth, reddish gray, becoming dark gray or brown; dark gray and smooth on young stems, on old trunks thick, deeply furrowed into broad, scaly ridges. Plate VII.

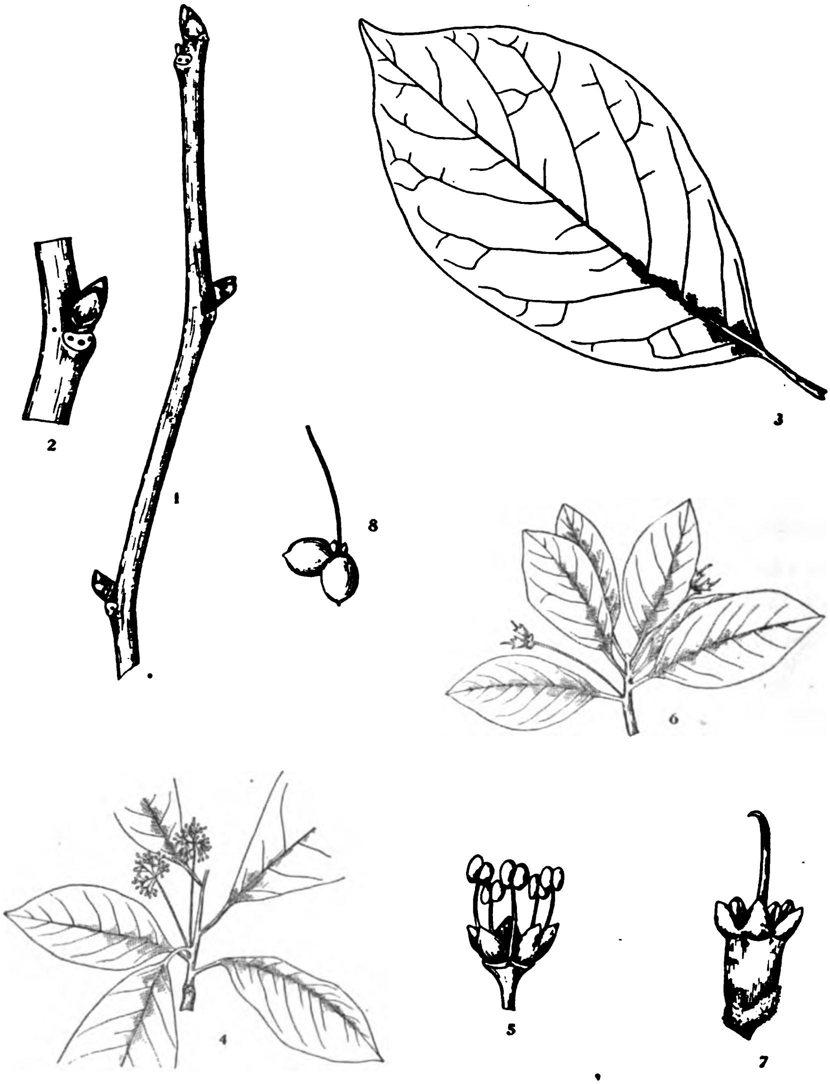
WOOD.—Light, soft, close-grained, tough, light red-brown, with thick sapwood of nearly the same color. Page 231.

DISTRIBUTION.—Common throughout Vermont at altitudes less than 1,000 feet, rare from 1,000-2,000 feet.

HABITAT.—Prefers rich, well-drained, loamy soils.

NOTES.—The basswood is a widely scattered tree in Vermont, growing with the maples, oaks and elms. Its leaves are five or six inches long and nearly as wide, with a base more deeply cordate on one side than the other. The flowers, which open in July, are creamy-white, borne in clusters suspended from a tongue-like leaf or bract. They are very fragrant and so full of nectar that the basswood often is called the bee-tree. The fruit ripens in autumn, forming hard brown balls or nutlets the size of peas. Basswood lumber is brownish or nearly white, light but rather tough, and is extensively used for drawers and similar cabinet work, panels, inside wood-work and for toys. Owing to the fact that it is bent readily, it is used for the bodies and dash boards of carriages and sleighs. The European linden (*T. europea*) occasionally is cultivated. It closely resembles the American species.

Black Gum. Tupelo



(Mich. Trees).

1. Winter twig, x 1.
2. Portion of twig, enlarged.
3. Leaf, x ¾.
4. Staminate flowering branchlet, x ½.
5. Staminate flower, enlarged.
6. Pistillate flowering branchlet, x ½.
7. Pistillate flower, enlarged.
8. Fruit, x ½.

CORNACEAE

Black Gum. Tupelo

Nyssa sylvatica Marsh. [Nyssa multiflora Wang.]

HABIT.—A medium-sized tree 20-40 feet high, with a trunk diameter of 1-2 feet, forming a rounded to cylindrical crown of slender, spreading, pendulous branches and a stiff, flat spray.

LEAVES.—Alternate, simple, 2-5 inches long, one-half as broad; oblong-obovate to oval; entire, or sometimes wavy-margined; thick and firm; very lustrous and dark green above, pale and often hairy beneath, turning bright scarlet, on the upper surface only, in autumn; petioles short.

FLOWERS.—May-June, with the leaves; polygamo-dioecious; greenish; borne on slender, downy peduncles; the staminate slender-pedicelled, in many-flowered heads; the pistillate sessile, in several-flowered clusters; calyx cup-shaped, 5-toothed; petals 5; stamens 5-10; stigma stout, terete, recurved.

FRUIT.—October; fleshy drupes, ovoid, blue-black, about ½ inch long, sour, in clusters of 1-3.

WINTER-BUDS.—⅛-¼ inch long, ovoid, obtuse, dark red.

BARK.—Twigs greenish or light brown, smooth or often downy, becoming smooth, dark red-brown; thick, red-brown on old trunks, deeply furrowed. Plate VIII.

WOOD.—Heavy, soft, strong, very tough, difficult to split, not durable in contact with the soil, pale yellow, with thick, whitish sapwood.

DISTRIBUTION.—Occasional along the shores of Lake Champlain and in the adjacent river-bottoms; also in southwestern Vermont; has been found in central Vermont as far north as Craftsbury.

HABITAT.—Prefers the borders of swamps and low, wet lands. Rarely flourishes in exposed situations.

NOTES.—The sour gum has a peculiar appearance with horizontal branches and smooth or glossy leaves, borne in beech-like sprays. Its greenish flowers appear in June and are followed by the dark-blue, egg-shaped fruits, one-half of an inch long, with thin, acid flesh, ripening in October. It is of great ornamental value when planted within its range.

THE ASHES

The olive family takes its name from the olive tree of Asia. The only representatives among our native trees are the ashes; but several of the commonly planted ornamental shrubs, the lilacs and other syringas and the beautiful forsythia, belong to this family.

The individual flowers of the ashes are small; but coming as they do before the leaves and appearing in crowded clusters, they are quite conspicuous. The flowers are of two kinds, the pollen producing and the seed bearing being on separate trees. The ashes, like the maples, have prominently winged fruit, but those of the ash hang singly whereas the maple "keys" are always in pairs.

The ashes are among the most useful of the hardwood forest trees of America, yielding to the oaks alone in value. Two species, the black ash and the white ash, occur commonly throughout Vermont, the red ash and the green ash are restricted or local in their distribution. The latter two are very similar and intermediate forms connect them so closely that some authorities rate the green ash as but a variety of the red ash. In using the following key it is to be observed that the ash leaf is compound, that is, each leaf is divided into from seven to eleven smaller leaflets, as will be seen by examining any of the figures.

SUMMER KEY TO THE SPECIES OF FRAXINUS

a. Lateral leaflets sessile .... **F. nigra,** p. 193.

aa. Lateral leaflets petioled.

  b. Twigs, petioles and lower sides of leaves pubescent, **F. pennsylvanica,** p. 189.

  bb. Twigs, petioles and lower sides of leaves essentially glabrous.

    c. Lower sides of leaves essentially of the same color as the upper; leaflet-margins rather finely sharp-serrate, **F. pennsylvanica lanceolata,** p. 191.

    cc. Lower sides of leaves paler than the upper; leaflet-margins entire or obscurely serrate .... **F. americana,** p. 187.

WINTER KEY TO THE SPECIES OF FRAXINUS

a. Buds rusty-tomentose; twigs more or less downy, **F. pennsylvanica,** p. 189

aa. Buds not tomentose; twigs not downy.

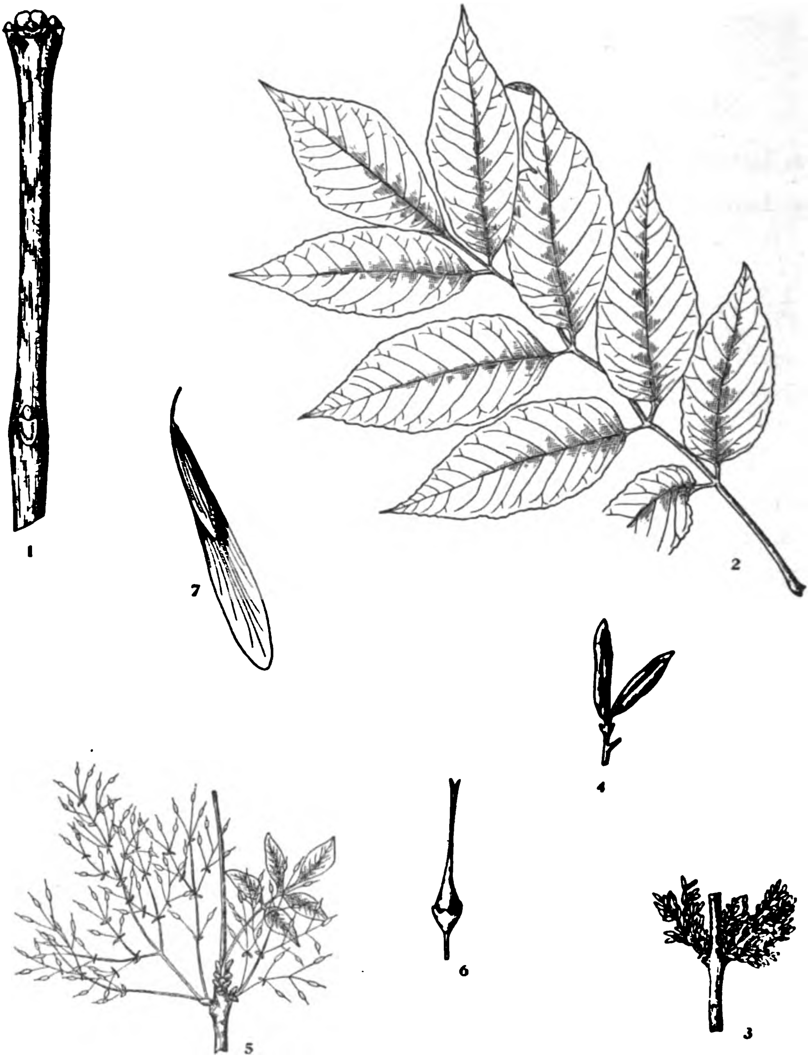
  b. Terminal bud black or nearly so, showing 3 pairs of scales in cross-section; bud-scales apiculate at the apex; samaras with broad wings, the seed portion flattish; bark flaky, rubbing off on the hand .... **F. nigra,** p. 193.

  bb. Terminal bud brownish, showing 4 pairs of scales in cross-section; bud-scales rounded at the apex; samaras with narrow wings, the seed portion terete; bark ridged, not flaky and rubbing off on the hand.

    c. Upper margin of leaf-scars deeply concave, **F. americana,** p. 187.

    cc. Upper margin of leaf-scars not concave, but straight across or projecting upward..... **F. pennsylvanica lanceolata,** p. 191.

White Ash



(Mich. Trees).

1. Winter twig, x 1.
2. Leaf, x ¼.
3. Staminate flowering branchlet, x ½.
4. Staminate flower, enlarged.
5. Pistillate flowering branchlet, x ½.
6. Pistillate flower, enlarged.
7. Fruit, x 1.

OLEACEAE

White Ash

Fraxinus americana L.

HABIT.—A large tree 50-75 feet high, with a trunk diameter of 2-3 feet; forming an open, pyramidal crown of long, slender, lateral branches and a stout, rather sparse spray.

LEAVES.—Opposite, pinnately compound, 8-12 inches long. Leaflets usually 7-9, 3-5 inches long, 1-2 inches broad; short-stalked; ovate to oblong-lanceolate; entire or obscurely serrate; thick and firm; glabrous, dark green above, paler beneath. Petioles glabrous, stout, grooved.

FLOWERS.—May, before the leaves; dioecious; borne in loose panicles on shoots of the previous season; calyx campanulate, 4-lobed; corolla 0; stamens 2, rarely 3; ovary 2-celled.

FRUIT.—August-September, persistent on the branches until mid-winter or the following spring; samaras 1-2 inches long, in crowded, drooping, paniculate clusters 6-8 inches long.

WINTER-BUDS.—Short, rather obtuse; bud-scales apiculate, keeled, 4 pairs, rusty-brown.

BARK.—Twigs at first dark green, becoming gray or light brown, often covered with a glaucous bloom; gray, deeply furrowed into firm, narrow, flattened ridges on the trunk. Plate VIII.

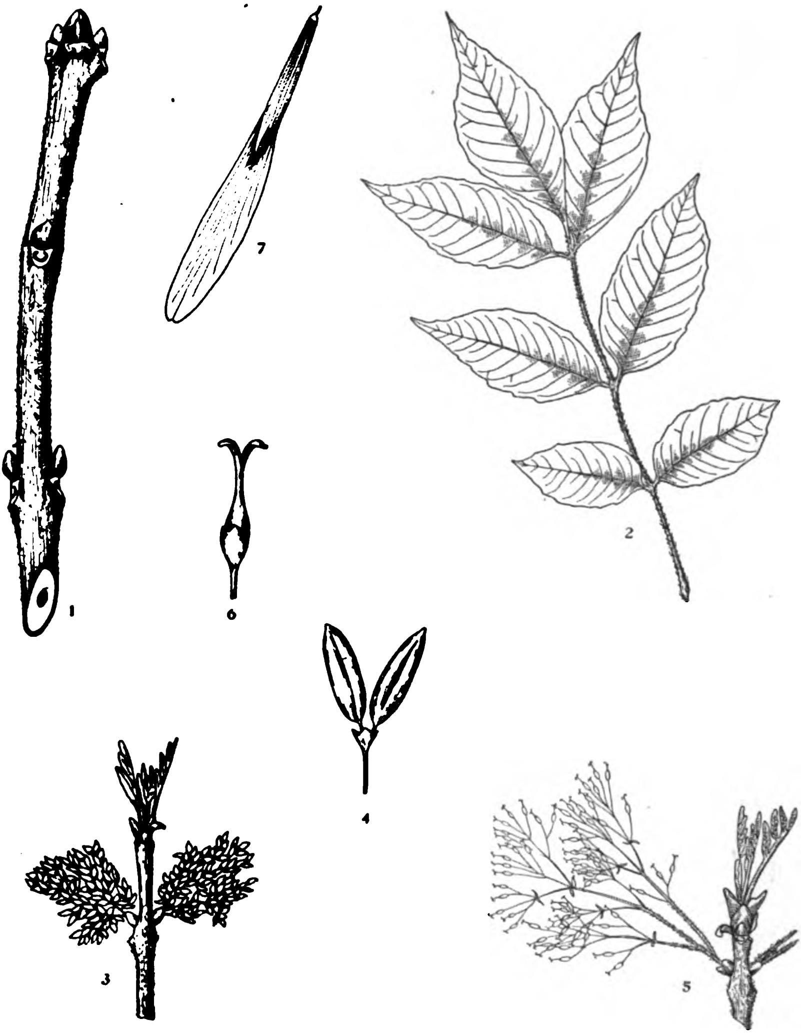
WOOD.—Heavy, hard, strong, close-grained, tough, brown, with thick, lighter colored sapwood. Page 225.

DISTRIBUTION.—Of common occurrence throughout Vermont.

HABITAT.—Prefers a rich, moist, loamy soil, but grows in any well-drained situation; common along stream-beds.

NOTES.—The white ash occurs in all parts of Vermont and upon all kinds of soil, but it prefers a rich, moist location. It is an open spreading tree in the field but in the forest it sends up a clean, straight shaft with a very small head. This character helps to make the white ash one of the valuable timber trees of our forests. The wood is strong, tough, elastic, durable and easily worked. It is manufactured into casings, every kind of furniture, agricultural implements and parts of carriages. It is said that in strength and elasticity the white ash timber from Vermont is superior to that from most other sources. The white oak and the hickories are the only native trees which have a higher value for fuel. This ash is recognized by its compound leaves, nearly twelve inches long, with from seven to nine smooth, petioled leaflets.

Red Ash



(Mich. Trees).

1. **Winter twig, x 1.**
2. **Leaf, x ⅓.**
3. **Staminate flowering branchlet, x ½.**
4. **Staminate flower, enlarged.**
5. **Pistillate flowering branchlet, x ½.**
6. **Pistillate flower, enlarged.**
7. **Fruit, x 1.**

OLEACEAE

Red Ash

Fraxinus pennsylvanica Marsh. [Fraxinus pubescens Lam.]

HABIT.—A medium-sized tree 30-50 feet high, with a trunk diameter of 1-2 feet; stout, upright branches and slender branchlets form a compact, broad, irregular crown.

LEAVES.—Opposite, pinnately compound, 10-12 inches long. Leaflets 7-9, 3-5 inches long, 1-1½ inches broad; short-stalked; oblong-lanceolate to ovate; slightly serrate or entire; thin and firm; glabrous, yellow-green above, pale and silky-downy beneath. Petioles stout, pubescent.

FLOWERS.—May, with the leaves; dioecious; borne in compact, downy panicles on shoots of the previous season; calyx cup-shaped, 4-toothed; corolla 0; stamens 2, rarely 3; ovary 2-celled.

FRUIT.—Early autumn, persistent on the branches throughout the winter; samaras 1-2 inches long, in open, paniculate clusters.

WINTER-BUDS.—Small, rounded; bud-scales rounded on the back, 3 pairs, rusty brown, tomentose.

BARK.—Twigs pale pubescent at first, lasting 2-3 years or often disappearing during the first summer, finally ashy gray or brownish and often covered with a glaucous bloom; brown or dark gray on the trunk, with many longitudinal, shallow furrows; somewhat scaly.

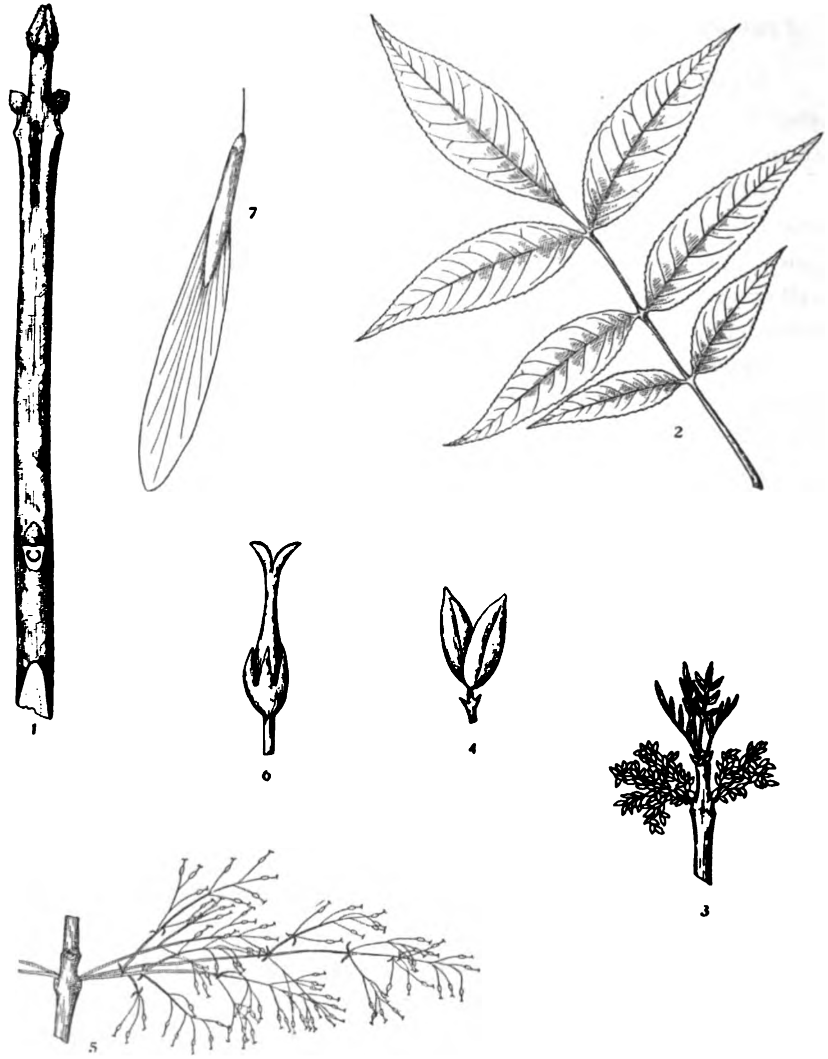
WOOD.—Heavy, hard, strong, brittle, coarse-grained, light brown, with thick, yellow-streaked sapwood.

DISTRIBUTION.—Common along Lake Champlain and its tributaries; occasional in other sections.

HABITAT.—Wet or moist, rich loam; river-banks; swampy lowlands.

NOTES.—The red ash closely resembles the white ash in general appearance. It may be recognized always, however, by looking closely at the buds in winter or at the young shoots or petioles in summer. These parts are velvety with delicate hairs, and it is this characteristic pubescence which suggested the Latin name of the species. The flowers and fruits bear a general resemblance to those of the white ash. The red ash is used considerably in manufactures but is inferior to the preceding species for most purposes. It is distributed generally along the shores of Lake Champlain and its adjacent waters but has not been reported from other parts of Vermont.

Green Ash



(Mich. Trees).

1. **Winter twig, x 1.**
2. **Leaf, x ⅓.**
3. **Staminate flowering branchlet, x ½.**
4. **Staminate flower, enlarged.**
5. **Pistillate flowering branchlet, x ½.**
6. **Pistillate flower, enlarged.**
7. **Fruit, x 1.**

OLEACEAE

Green Ash

Fraxinus pennsylvanica lanceolata (Borkh.) Sarg. [Fraxinus lanceolata Borkh.] [Fraxinus viridis Michx. f.]

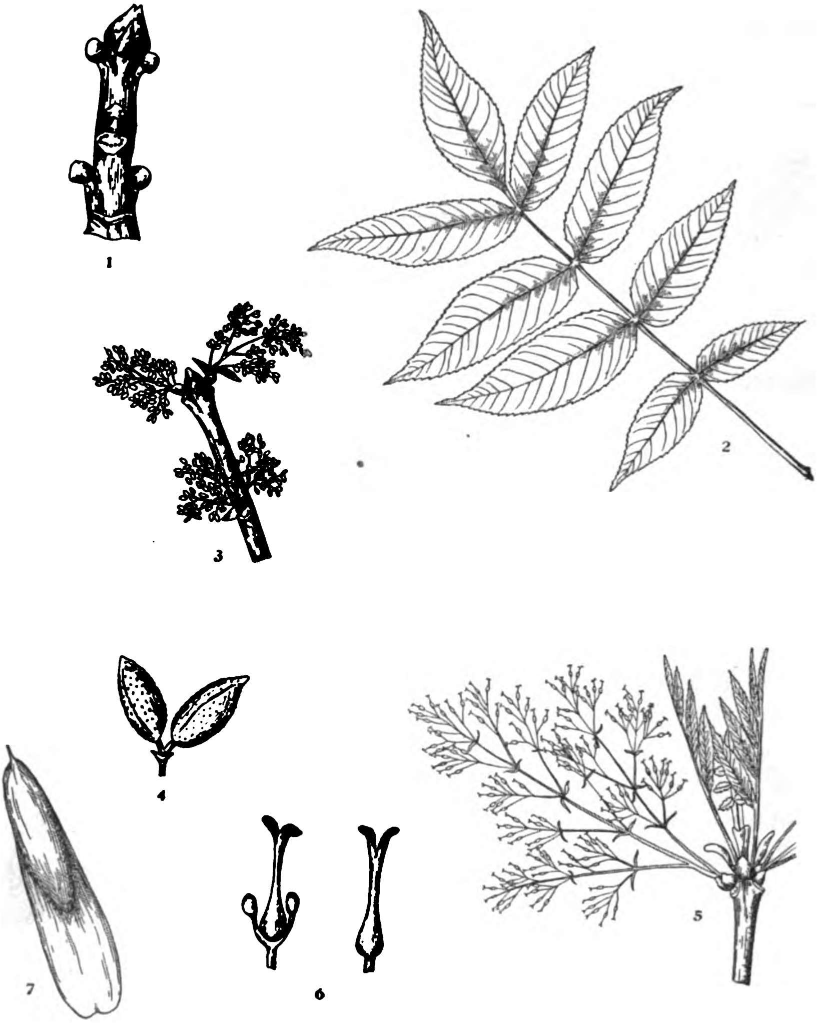
Considered by some authors to be a distinct species, and by others a variety of *F. pennsylvanica Marsh.*, which it resembles. The main points of difference are:

> The usual absence of pubescence from the branchlets, the under side of the leaflets, and the petioles.
>
> The rather narrower, shorter, and more sharply serrate leaflets.
>
> The color of the leaves, which is bright green on both sides.

A very hardy tree, of rapid growth and desirable habit, making it useful for ornamental and street planting. Easily transplanted.

The green ash occurs occasionally along the shores of Lake Champlain.

Black Ash



(Mich. Trees).

1. Winter twig, x 1.
2. Leaf, x ⅓.
3. Staminate flowering branchlet, x ½.
4. Staminate flower, enlarged.
5. Pistillate flowering branchlet, x ½.
6. Pistillate flowers, enlarged.
7. Fruit, x 1.

OLEACEAE

Black Ash

Fraxinus nigra Marsh. [Fraxinus sambucifolia Lam.]

HABIT.—A tall tree 60-80 feet high, with a trunk diameter of 1-2 feet; slender, upright branches form in the forest a narrow crown, in the open a rounded, ovoid crown.

LEAVES.—Opposite, pinnately compound, 12-16 inches long. Leaflets 7-11, 3-5 inches long, 1-2 inches broad; sessile, except the terminal; oblong to oblong-lanceolate, long-pointed; remotely, but sharply serrate; thin and firm; dark green above, paler beneath, glabrous. Petioles stout, grooved, glabrous.

FLOWERS.—May, before the leaves; polygamo-dioecious; borne in loose panicles on shoots of the preceding season; calyx 0; corolla 0; stamens 2; ovary 2-celled.

FRUIT.—August-September, falling early, or sometimes hanging on the tree until the following spring; samaras 1-1½ inches long, in open, paniculate clusters 8-10 inches long.

WINTER-BUDS.—Ovoid, pointed; bud-scales rounded on the back, 3 pairs, almost black.

BARK.—Twigs at first dark green, becoming ashy gray or orange, finally dark gray and warted; thin, soft ash-gray and scaly on the trunk. Bark flakes off on rubbing with the hand. Plate VIII.

WOOD.—Heavy, tough, coarse-grained, weak, rather soft, dark brown, with thin, lighter colored sapwood.

DISTRIBUTION.—Common throughout the lower altitudes.

HABITAT.—Deep, cold swamps and low river-banks; wet woods.

NOTES.—The black ash is found in lowlands and swamps. Often it is called the brown ash but this name is confusing as it is applied also to the red ash. This and the white ash are the commoner species of Vermont. They are distinguished easily by the fact that the leaflets of the white ash always are distinctly stalked while the black ash has sessile leaflets. These are seven to eleven in number, often forming a leaf twelve to sixteen inches long which is smooth and green on both sides. Black ash timber is coarser-grained than is that of white ash. It is used for furniture and interior finishings and in the manufacture of baskets.

THE STRUCTURE AND IDENTIFICATION OF OUR COMMON LUMBER WOODS

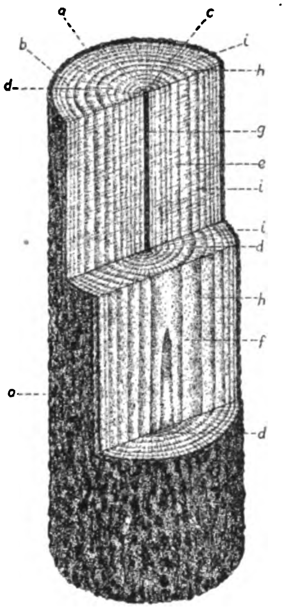
By C. H. OTIS

Common as wood is in its varied forms and uses, comparatively few people are able to distinguish our familiar trees when sawed into lumber and fashioned into houses, furniture and other manufactured products. Yet each wood has characteristics of color, odor, graining, weight, hardness, strength and minute structure peculiar to itself which distinguish it from other woods.

The value of each kind of wood for building purposes and every other use is determined to a large extent by its characteristics. These, taken in connection with the available supply of any particular timber in the country, govern the value or cost of that timber in the lumber market. So certain trees, like oak and cedar, because of their durability in contact with the soil, make admirable fence posts; spruce and the broad-leaved white birch and cottonwood possess structural qualities adapting them to the manufacture of paper pulp; hickory, very strong, tough and straight-grained, has long been valued for carriage and wagon stock and tool handles. Many examples might here be cited to show how various woods are peculiarly adapted to certain uses to a greater extent than are others. Again, some species, on account of our wasteful methods of lumbering, failure to provide means of reproduction and lack of restriction as to particular uses, have become so scarce that substitutes are offered in the markets to take their places. To such an extent has this become true that methods are in use to imitate the grain and color of some of the more depleted but valuable woods. Thus birch enters very largely into the composition of a great deal of so-called modern mahogany furniture, and cheap woods are often grained to imitate quarter-sawed white oak.

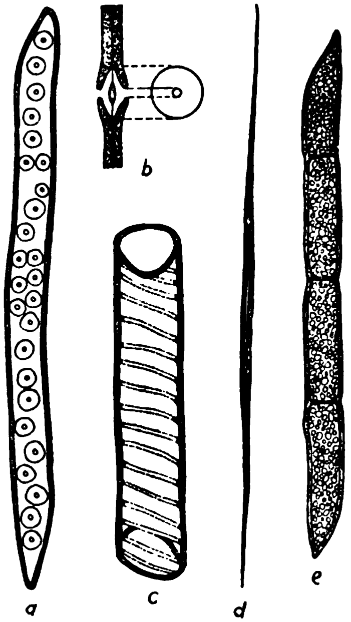
With the great variety of useful woods to be found in any lumber yard, it is important that consumers of wood in any form should be able to identify the different kinds offered so that they may choose those woods best suited to their particular needs and that they may obtain them and not lumber similar in appearance but otherwise of inferior qualifications.

Wood structure and the arrangement of the elements making up the woody tissues constitute the basis of the identification and use of timber. By structure is meant the relative size, shape and form of the wood elements peculiar to each tree. It is by reason of their structure that some woods are heavier, stronger and stiffer than others, that some are straight- and others are cross-grained, that some are hard and some soft and that some season rapidly and without injury while others have a tendency to check and split. The wide medullary rays of the oak explain the pleasing effect of the wood when quarter-sawed and polished to bring out the grain. The peculiar undulations of the growth rings sometimes found in the maple produce the "bird's-eye" markings which make the lumber so prized in the manufacture of furniture. It is our purpose to consider briefly the structure of a tree trunk and the various elements of the woody tissues.



VIII. **Log Cut to Show Features.**

a. **Bark.**
b. **Sapwood.**
c. **Heartwood.**
d. **Cross-section.**
e. **Radial-section.**
f. **Tangential-section.**
g. **Pith.**
h. **Growth ring.**
i. **Medullary ray.**



IX. **Typical Wood Elements, Diagrammatic. Greatly Enlarged.**

a. **Tracheid, showing bordered pits.**
b. **Scheme of bordered pit in section and surface views.**
c. **Segment or single cells of a vessel, showing spiral thickenings.**
d. **Wood or bast fiber.**
e. **Group of wood-parenchyma cells.**

If we should go into a forest where felling operations are in progress or into a sawmill where there are unsawed logs, we would have an opportunity to examine the smooth-cut end of a mature log. We would note that it exhibits several well-defined areas or layers.

The first layer on the outside is probably rough externally and dark-colored. This is the bark, (a, fig. VIII), a protective covering to the inner woody tissues. The outer portion of the bark of a forest tree is dead tissue which is stretched and fissured as the tree grows in diameter, while the inner portion is live tissue, serving to conduct food materials up and down the trunk. In some kinds of trees the bark is quite thick, in others very thin. This factor, together with those of color and external appearance, makes the bark, when present, of considerable value in the determination of woods. At the center of the log is a small cylinder of loose tissue less than one-fourth of an inch in diameter, the pith (g, fig. VIII). Lying between the bark and the pith is the wood. In some kinds of trees, like the balsam fir and the hemlock, the wood is all of one color. In others, it consists of two parts distinct from each other in color. The outer portion is called sapwood (b, fig. VIII). It is living tissue and serves chiefly in the living tree to conduct the sap, or water which is taken up by the roots, to the leaves. The width of the sapwood varies with different species and with different individuals of the same species. In very young trees all the wood is sapwood. As the sapwood grows older, the tissue composing it becomes choked so as to prevent the further passage of sap. This tissue then dies and serves only as a support to the rest of the tree, holding up its great weight and making it rigid enough to resist strong winds. It usually becomes darker colored than the sapwood, and is called heartwood (c, fig. VIII). The sapwood and heartwood differ not only in color, but also in durability. In some species only the heartwood is suitable for sawing into lumber, being, as a rule, harder, heavier and drier than sapwood. In other cases where pliability or elasticity is required, as, for example, in hickory and ash which are used in making baskets or for handles of rakes, hoes and golf clubs, the sapwood is more valuable than the heartwood.

Separating the wood from the bark is a very thin layer, the cambium. From this layer is added new wood on the outside of that already formed and new bark on the inside of the old bark. It is by this process that the trunk grows in diameter. Each year the cambium adds a new layer of wood to the circumference of the tree. These layers appear on the end of the log as concentric rings. They are called annual, yearly or growth rings (h, fig. VIII). In maple, birch, white pine and many other woods there is no sharp distinction between the wood formed in the spring and that formed in summer. In other cases the wood which is formed in the spring, when growth is most rapid, differs in nature from the harder and denser wood formed later in the season. The oaks, elms and hickories present clearly defined layers. The two layers are called early or spring wood and late or summer wood. The presence or absence of well-defined spring and summer wood is an important factor in distinguishing and naming the different woods; in fact, the grain or figure of some kinds of lumber depends entirely upon the difference between spring and summer wood.

Radiating from the center of the trunk toward the bark, like the spokes of a wheel, are slender but more or less distinct lines. These are the medullary rays (i, fig. VIII). Medullary rays serve two functions; they are paths for the conduction of food materials between bark and wood or wood and bark, and they bind the trunk together from pith to bark. Woods differ in the size and number of medullary rays present, the rays being inconspicuous in some and very prominent in others. If an oak log be cut along any of its many radii, i. e., parallel to one of the lines of the medullary rays, the beautiful "flakes" of the quarter-sawed oak are exposed to view. In other trees, like the maples, the medullary rays may be so small as to escape notice. But whether prominent or inconspicuous, the medullary rays help largely to make up the pattern which often readily and surely distinguishes one wood from another.

We have learned from our superficial inspection that a tree is not a simple structure but a complex organism composed of several kinds of tissues, each having its particular function in the life of the tree. In order to continue our study further, it is necessary that we use a hand lens or a compound microscope. If we examine the smoothly cut end of a piece of wood, or, better, a very thin shaving, we find that it is seemingly made up of a network of holes or pores held together by chains of solid tissue, in appearance resembling the chambers of a honeycomb. All trees, all tissues composing trees, are made up of millions of these units, just as a wall is built of bricks and mortar. These units making up the bodies of trees are called cells (fig. IX). A cell may be considered in the nature of a box, but so small is it that it is usually indistinguishable to the naked eye. The walls of the box or cell are composed for the most part of a woody substance called cellulose; we call them cell-walls. In young cells, such as we find in the actively growing parts of trees, the whole cavity of the cell is filled with a slimy substance called protoplasm. The protoplasm is the living substance of the tree; where there is protoplasm, there is life and growth. As the cells grow older and larger, the protoplasm does not continue to fill the whole cavity within the cell-walls, but forms only a thin lining around the walls. Finally it disappears altogether, leaving the dead cell-walls intact, making the substance called wood. The cells composing wood are not all the same shape or size, but vary greatly according to the function which they serve in the life of the tree. Because of the great variety of the cells composing it, wood takes on various characters of structure, graining and coloring, which are distinctive for each kind of wood and which greatly aid in distinguishing the various kinds from one another.

The wood of conifers is very regular and simple, consisting mainly of cells of one sort. It is this uniformity of structure which makes the wood of conifers valuable for so many purposes. These cells are called tracheids (a, fig. IX). They are vertical, elongated, tapering tubes, one-twentieth to one-fifth of an inch in length, with closed ends and a relatively large cavity. The pointed ends of the tracheids overlap one another in a dovetailed fashion, breaking the joints and making the wood much stronger than it would be otherwise. They are further identified by the presence of pits or pores in their walls which serve as waterways between the tubes. These pits (b, fig. IX) appear as if made up of two circles, and they are for this reason called bordered pits. The other cells making up the wood of conifers are the ray cells. These extend horizontally, and in a radial-section appear as tiers of regular, brick-shaped cells. The cells communicate with one another by numerous pits in the walls. In certain genera the medullary rays are bordered by tracheids similar to the ordinary wood tracheids, but designated as ray tracheids. In one of the pines the ray tracheids have teeth-like projections from the walls, which are useful in identifying this species. Scattered here and there on the cross-section of some coniferous woods are to be seen irregular grayish or brownish dots. These are resin ducts and are especially well-represented in the pines. Resin ducts are openings between cells containing resin, which is manufactured by certain trees. If you cut a limb from a pine tree, the cut surface will very quickly become sticky with the resin which oozes from these ducts. On a warm day in the pine woods the resin is quite apparent by its fragrant odor. Some woods have present also certain cells or groups of cells which produce resin, which gives them a distinctive appearance, and therefore they are called resin cells. Their presence or absence aids in the determination of certain woods.

The wood of broad-leaved trees is much more complex in structure than the wood of conifers. Instead of being made up essentially of one kind of cells, tracheids, as is the case in the coniferous woods just mentioned, the wood of broad-leaved trees is composed of several kinds of cells. If we examine the cut end of a red oak branch we notice that the spring wood contains many comparatively large openings which are visible even to the naked eye. These openings are called pores; they are cross-sections of open tubes or vessels or tracheae which run up and down the trunk of the tree and out into the branches and twigs. In the beginning they resembled the tracheids of conifers, i. e., they were made up of separate and distinct cells. Later, the end walls of the cells which met endwise were absorbed, leaving a continuous series of connected cells or a tube (c, fig. IX). These tubes or vessels serve in the living tree as water-carriers. For the sidewise conduction of fluids, the vessels are usually abundantly pitted with bordered pits, but the pits are somewhat smaller than those commonly found in the tracheids of coniferous woods. Furthermore, it is very common for vessels, especially the smaller ones, to be marked with spiral thickenings on their interior walls. The scalariform perforations present in the end partitions of the vessels of a few woods, as seen on the radial-section, are sometimes confused with the true spiral thickenings just mentioned. This point may be definitely determined by an inspection of tangential- as well as radial-sections. Tyloses also occur in the vessels of many of the broad-leaved woods, sometimes being visible to the naked eye. Tyloses are usually rather thin-walled cells which protrude into the cavities of the vessels, where they divide rapidly and grow, sometimes filling the entire cavity and plugging the vessels so as to prevent further conduction of fluids. The value of white oak for cooperage is increased by tyloses, which are especially abundant in the vessels of this wood. They are also well-represented in the locust, in this instance being rather thick-walled.

It is convenient to divide broad-leaved woods into two groups, which are characterized by the size and arrangement of the vessels. In some species of wood the vessels which are formed later in the season are much smaller than those formed earlier. A wood of this kind, with its large pores collected into a row or band in each growth ring, is spoken of as ring-porous. In other woods, the pores are more nearly uniform in size in both spring and summer wood. They are designated as diffuse-porous woods. The wood of the maple is of this character. In many of the diffuse-porous woods the pores are too small to be seen with the naked eye, and in some cases they may even be indistinct when viewed with a lens. They should not, however, because of this, be confused with the non-porous coniferous woods, which they may resemble.

Tracheids in the wood of broad-leaved trees are subordinate elements. They are much smaller and less uniform in size and shape than in conifers and are more abundant in the vicinity of the tubes or vessels. As in conifers, the tracheids bear numerous bordered pits on their walls. In some cases, as in the wood of the ash, tracheids are absent.

Strength, hardness and toughness are given to broad-leaved woods principally by the wood fibers. These are slender, spindle-shaped, sharp-pointed cells with thick walls and narrow cavities (d, fig. IX). Usually they are provided with oblique, slit-like, simple pits. The wood fibers for the most part lie vertically side by side and parallel to one another, but in some woods, like the sycamore, they are more or less interwoven. This makes the wood cross-grained, difficult to work and hard to split.

While the medullary rays of coniferous woods are uniformly small and inconspicuous, they are often broad and prominent in broad-leaved woods. They are largest in the oak, where they may become twenty-five to seventy-five cells wide and several hundred cells high; between these broad rays are numerous smaller ones, mostly uniseriate and from one to twenty cells high. In the sycamore all the rays are broad, while in the beech only a portion of the rays are broad. Ray cells are usually elongated in the radial or horizontal direction and are then termed procumbent. Not infrequently, however, the marginal cells, as in the willow, are elongated vertically; cells of this kind are said to be upright. These differences in the character of the medullary rays are important means of identification.

Another kind of tissue which is more or less prominent in broad-leaved woods is wood parenchyma. Parenchyma consists of vertical groups of short cells, the end ones of each group tapering to a point (e, fig. IX). The cells of parenchyma resemble the cells of the medullary rays; the walls are invariably pitted with rounded, simple pits. The function of the parenchyma is the distribution and storage of the food products manufactured by the leaves. The distribution of parenchyma on the cross-sections of different species is subject to more or less variation, making this feature of considerable importance in classifying woods. Commonly wood parenchyma is grouped around the pores or vessels. In the basswood it occurs in somewhat broken, tangential lines, forming, with the wood fibers, a tier-like arrangement of the wood elements. In the hickory it forms numerous, fine, concentric lines which are as distinct as the rays. In other woods it may be confined to several rows of cells at the outer limit of the growth ring.

As a final feature having some value in the identification of certain of the woods, is to be mentioned the so-called "pith flecks". They are common in many of our native woods, appearing as crescent-shaped, discolored patches on the cross-section and as brownish streaks running up and down the stem in longitudinal-section. Pith flecks are not a special kind of tissue, but are tunnels made by the larvae of a two-winged insect which lives in the cambium during the growing season. These pith flecks have been found to occur in only five families of trees in the United States, namely, the willow, birch, rose, maple and linden families. They are by no means constant in their occurrence; some stems have numerous pith flecks, while other stems of the same species from the same vicinity do not have them. Taken in conjunction with other characters, however, the presence of pith flecks in considerable numbers may aid in the identification of woods.

The subject of wood structure is one of absorbing interest to one who will but take a little trouble to go beneath the surface. Facts will be revealed which have hitherto lain hidden because of our usual cursory method of handling wood. Some practise may be necessary at first, a little patience may be needed at times, but success will be the reward of honest effort. In all identification work a very sharp knife is necessary. Surfaces must be cut cleanly and smoothly, keeping always in mind that a bruised and broken surface reveals but little of the structure of the wood. Large pieces are not essential, even small cuts along the edge will often suffice. Twigs cut easier than seasoned boards and are frequently as instructive as the more mature wood. Wetting the cut surface will usually make the structural features more prominent. Instructive sections may be made with a very sharp knife or razor, or even with a plane, by cutting very thin pieces and mounting them in water or glycerin between two thin pieces of glass. The sections may even be colored to advantage by soaking them for a time in a dye, thus making certain features more evident. Transparent water colors such as are used in coloring photographs and prints are generally available and will be found to serve as well as the usual laboratory stains. The mounts may be examined with a hand lens by holding them between the eye and the light, or they may be viewed with a compound microscope. If the latter is employed, the sections of wood must be cut very thin and the customary thin cover-glass must be used between the wood-section and the microscope lens.

In the key to the woods which follows, it will be noticed that two large divisions have been made, one the porous woods, being the great mass of broad leaved woods, the other the non-porous or coniferous woods. Porous woods have again been divided into two groups, the ring-porous woods and the diffuse-porous woods. The key is constructed on the same principles which have been employed throughout in other keys in this bulletin. For an explanation and illustration of the manner of using a key, the reader is referred to the chapter on "Artificial Keys, How Made and Used" (pages 13 to 15). Attention is called to the fact that both naked-eye and microscopic characters have been introduced into the key to the woods. Naked-eye characters are printed in Roman type, the microscopic in italics. While keys based solely upon naked-eye or macroscopic characters have been published, their use often leads the beginner to wrong conclusions or utter confusion. The insertion of microscopic characters may be considered, then, as a necessary affliction which has been imposed to make accurate determinations easy, rather than to complicate the key. The more common or important woods have been illustrated by cross-, radial- and tangential-sections of the woods. In the preparation of these drawings, photomicrographs of very thin, stained sections of typical wood were taken. Blueprints were subsequently made from the negatives and the outlines of the cells were drawn in with India ink. Finally the prints were bleached, the result being a silhouette of the original wood-section drawn accurately to a scale on a white background.

KEY TO THE WOODS OF VERMONT

In the following key, the Roman type calls attention to characters which may readily be distinguished by the naked eye or by the use of a hand lens, and should not be interpreted as indicating more important characters. The italics represent characters that can be studied only with a compound microscope.

The word in parenthesis indicates the section, cross-, radial-, tangential- or longitudinal-, which shows the point in question to greatest advantage.

a.[1] Pores (cross) visible and conspicuous, at least with magnifier, *i. e., wood composed of three to six kinds of cells, which are not uniform in structure and usually not arranged in definite radial rows;* resin ducts and resin cells (cross) absent; rays (cross) for the most part conspicuous.

b. Growth rings (cross) defined by zones of large pores in the spring wood alternating with the denser summer wood; pores in summer wood small, or few and scattered.

c. Rays (cross), or part of them, broad, easily distinguishable by the naked eye at three feet distance; on close inspection, rays of two kinds, broad and fine.

d. Pores (cross) abruptly diminishing in size from spring wood to summer wood; *tyloses* (*longitudinal*) *present, usually abundant in all large pores.*

e. Pores (cross) of spring wood 1-3 rows deep.

f. Pores (cross) of summer wood arranged chiefly in single, radial rows, seldom joined tangentially, the rows extending to the periphery of the growth rings,

Quercus bicolor.

ff. Pores (cross) of summer wood arranged chiefly in double, radial rows, often joined tangentially, the rows rarely extending to the periphery of the growth rings.

g. Radial rows of summer-wood pores (cross) relatively wide; large rays about ¼ inch apart,

Quercus macrocarpa.

gg. Radial rows of summer-wood pores (cross) relatively narrow; large rays about ⅛ inch apart,

Quercus alba.

ee. Pores (cross) of spring wood 3-5 rows deep.

f. Radial rows of small pores (cross) chiefly in several rows, becoming wider toward the periphery of the growth rings; walls of summer-wood pores thin,

Quercus prinus.

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[1] ***aa.* See page 211.**

ff. Radial rows of small pores (cross) chiefly in one row, becoming narrower toward the periphery of the growth rings; walls of summer-wood pores thick, **Quercus muhlenbergii.**

dd. Pores (cross) gradually diminishing in size from spring wood to summer wood; *tyloses* (*longitudinal*) *usually scarce or wanting.*

e. *Wood-parenchyma cells* (*cross*) *arranged in concentric lines around the pores;* heartwood red-brown, **Quercus velutina.**

ee. *Wood-parenchyma cells* (*cross*) *grouped irregularly around the pores;* heartwood light red, **Quercus rubra,** p. 230.

cc. Pores (cross) all fine, indistinguishable by the naked eye at three feet distance; on close inspection, rays of one kind, all fine.

d. Pores (cross) of summer wood small and inconspicuous, or when visible single, grouped, or forming short, broken lines, but never forming extended radial or tangential lines.

e. Rays (cross) clearly distinct to the naked eye at 6-12 inches distance; growth rings for the most part wide to very wide; rays (radial) very high and prominent.

f. Pores (cross) of late summer wood in large groups *of 6-many, joined tangentially by wood parenchyma,* often forming tangential lines plainly visible to the naked eye at a distance of 6-12 inches; *tyloses* (*tangential*) *very abundant, densely plugging the vessels;* wood yielding a brown stain when rubbed with a wet, white handkerchief..........**Robinia pseudo-acacia.**

ff. Pores (cross) of late summer wood in small groups *of 3-6, not joined tangentially by wood parenchyma,* never forming tangential lines which are plainly visible to the naked eye at a distance of 6-12 inches; *tyloses* (*tangential*) *only fairly abundant, never plugging the vessels;* wood not yielding a brown stain when rubbed with a wet, white handkerchief.......**Morus rubra.**

ee. Rays (cross) not clearly distinct to the naked eye at 6-12 inches distance, inconspicuous to microscopic; growth rings (cross) for the most part narrow; rays (radial) not high and prominent.

f. Pores (cross) of summer wood *solitary, rarely grouped,* not forming short, tangential lines; wood parenchyma (cross) forming more or less continuous, tangential lines as distinct, or nearly so, as the rays; *tyloses* (*tangential*) *present* .... **Carya,** p. 229.

ff. Pores (cross) of summer wood *usually grouped,* for the most part forming short, tangential lines; wood parenchyma (cross) not forming continuous, tangential lines; *tyloses* (*tangential*) *absent.*

g. Pores (cross) of spring wood 1-2 rows deep, forming a narrow zone not over one-fourth the width of the growth ring.. **Fraxinus, pennsylvanica lanceolata.**

gg. Pores (cross) of spring wood 3-5 rows deep, forming a broad zone one-third to one-half the width of the growth ring.

h. Pores (cross) of summer wood *joined by wood parenchyma,* forming short or more or less extended, tangential lines; wood hard and strong.

i. Lines of pores and wood parenchyma (cross) in summer wood short and broken, mostly near the periphery of the growth ring (*occasionally absent or very indistinct*)..**Fraxinus americana,** p. 225.

ii. Lines of pores and wood parenchyma (cross) in summer wood long, more or less extended, usually well distributed through the growth ring................**Fraxinus pennsylvanica.**

hh. Pores (cross) of summer wood *not joined by wood parenchyma,* rarely forming tangential lines; wood soft and weak............**Fraxinus nigra.**

dd. Pores (cross) of summer wood small, but distinct, grouped or more or less confluent, or joined by wood parenchyma, to form wavy or branching, more or less extended, radial or tangential lines.

e. Pores (cross) of summer wood arranged in radial, branching lines (when very crowded, radial arrangement somewhat obscured); pores (cross) of spring wood plainly visible to the naked eye at a distance of two feet, *strongly oval or elliptical,* occupying nearly half the growth ring......................**Castanea dentata.**

ee. Pores (cross) of summer wood arranged, *or joined by wood parenchyma,* to form wavy or branching, tangential lines; pores (cross) of spring wood not plainly visible to the naked eye at a distance of two feet, *not strongly oval nor elliptical,* not occupying nearly half the growth ring.

f. Lines of summer-wood pores (cross) strongly wavy; *tyloses (tangential) mostly absent, not densely plugging the vessels;* wood not yielding a brown stain when rubbed with a wet, white handkerchief; growth rings (cross) not very wide.

g. Pores (cross) of spring wood in 3-many rows; pores (cross) of summer wood small, forming thin, rather broken and disconnected, tangential lines, not strongly wavy; heartwood chocolate-brown, **Ulmus fulva.**

gg. Pores (cross) of spring wood usually in a single row, or nearly so; pores (cross) of summer wood large, forming broad, mostly connected, tangential lines, strongly wavy; heartwood light brown or red.

h. Pores (cross) of spring wood large, plainly visible to the naked eye at a distance of 6-9 inches, forming a continuous row; texture coarse; wood hard to split ....**Ulmus americana,** p. 225.

hh. Pores (cross) of spring wood small, not visible to the naked eye at a distance of 6-9 inches, not forming a continuous row, but the larger ones few and rather widely separated; texture medium; wood fairly easy to split............**Ulmus racemosa.**

ff. Lines of summer-wood pores (cross) not strongly wavy; *tyloses (tangential) present, densely plugging the vessels;* wood yielding a brown stain when rubbed with a wet, white handkerchief; growth rings (cross) very wide ....**Robinia pseudo-acacia.**

bb. Growth rings (cross) not defined by zones of large pores in the spring wood, but pores all the same size, or nearly so, scattered more or less evenly through the growth ring, occasionally more numerous and very often somewhat larger in the spring wood.

c. Rays (cross) usually plainly visible to the naked eye at a distance of 6-9 inches.

d. Rays (cross) uniform, all of them more or less equal in size (see note below[1]).

e. Wood-parenchyma cells (cross) forming continuous or somewhat broken, tangential lines or bands, scarcely visible with a lens; wood light and soft.

f. Wood elements (cross) alternating with parenchyma elements in a tier-like arrangement; *vessels* (*tangential*) *with spirals; rays* (*tangential*) *very narrow, slender-tapering;* color light brown to nearly white, **Tilia americana,** p. 231.

ff. Wood elements (cross) not alternating with parenchyma elements in a tier-like arrangement, *but confined to 2-4 rows of flattened cells at the outer limit of the growth ring; vessels* (*tangential*) *without spirals; rays* (*tangential*) *rather wide, abruptly-tapering;* color bluish to the more common yellow-brown, often striped .... **Liriodendron tulipifera.**

ee. Wood-parenchyma cells (cross) not forming tangential lines or bands; wood moderately heavy and hard.

f. Ray cells (*radial*) *about as long as high; vessels* (*longitudinal*) *plugged at intervals with dark red gum;* color rich red-brown or wine.

g. Rays (cross) distinct to the naked eye; pith flecks (cross) usually absent; pores (cross) large and conspicuous under a hand lens.

h. Pores (cross) of the spring wood larger and more numerous than those of the summer wood; *larger rays* (*tangential*) *3-4-seriate;* wood rather soft, **Prunus nigra.**

hh. Pores (cross) of the spring wood not noticeably larger nor more numerous than those of the summer wood; *larger rays* (*tangential*) *6-8-seriate;* wood rather hard............. **Prunus serotina.**

gg. Rays (cross) barely visible to the naked eye; pith flecks (cross) usually present, often prominent; pores (cross) rather small and inconspicuous, even under a hand lens......... **Prunus pennsylvanica.**

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[1] The genus *Crataegus* apparently belongs here; but the wood varies so greatly and is of so little importance commercially that no attempt has been made to incorporate it within the key.

ff. *Ray cells* (*radial*) *about twice as long as high; vessels* (*longitudinal*) *not plugged at intervals with dark red gum;* color light brown to reddish.

g. Wood cream-white, without reddish tinge; rays (radial) not conspicuously darker than surrounding wood; growth rings (cross) usually very wide,

Acer negundo.

gg. Wood light red-brown to decidedly reddish; rays (radial) conspicuously darker than surrounding wood; growth rings (cross) usually moderately wide to narrow.

h. Larger rays (*tangential*) *4-6-seriate,* for the most part broader than the pores (cross); pith flecks absent or rare; growth rings more or less distinct; wood very heavy and hard,

Acer saccharum, p. 223.
Acer saccharum nigrum.

hh. Larger rays (tangential) *2-3-, or occasionally 4-seriate,* mostly narrower than the pores (cross); pith flecks present, often abundant; growth rings for the most part indistinct; wood rather light and soft.

i. Pores (cross) barely visible to the naked eye with close scrutiny; pith flecks (cross) usually small, neither abundant nor conspicuous,

Acer saccharinum.

ii. Pores (cross) visible to the naked eye with close scrutiny; pith flecks (cross) usually rather large, sometimes abundant, more or less conspicuous,

Acer rubrum.

dd. Rays (cross) not uniform, some of them conspicuously broad.

e. Rings (cross) strongly sinuous; wood white, not showing marked graining on tangential- and radial-sections; broad rays (cross) confined to short radii of the concave portions of the rings............... **Carpinus caroliniana.**

ee. Rings (cross) regular, not strongly sinuous; wood brownish to reddish, showing marked graining on tangential- and radial-sections; broad rays (cross) uniformly distributed, not confined to short radii.

f. Rays (cross) mostly all broad; *vessels* (*tangential*) *with spirals; rays* (*tangential*) *between broad rays rarely or never uniseriate;* wood cross-grained, difficult to split.................. **Platanus occidentalis.**

ff. Rays (cross) only part of them broad; *vessels* (*tangential*) *without spirals; rays* (*tangential*) *between broad rays mostly uniseriate;* wood mostly straight-grained, easy to split...... **Fagus grandifolia,** p. 227.

cc. Rays (cross) mostly not plainly visible to the naked eye at a distance of 6-9 inches, indistinct to microscopic.

d. Pores (cross), or some of them, plainly visible to the naked eye at a distance of a foot, mostly conspicuous in the spring wood, for this reason often approaching characteristics of ring-porous group; *squarish crystals in cells of wood parenchyma* (*longitudinal*) *common.*

e. Heartwood chocolate-brown, heavy and hard, with mild odor, especially when wet; *rays* (*tangential*) *mostly 2-3-seriate, thick-tapering*.................. **Juglans nigra.**

ee. Heartwood light chestnut-brown, light and soft, odorless, even when wet; *rays* (*tangential*) *mostly uniseriate, slender-tapering*...................... **Juglans cinerea.**

dd. Pores (cross) not visible to the naked eye at a distance of a foot, not conspicuous in the spring wood; *squarish crystals in cells of wood parenchyma* (*longitudinal*) *uncommon or wanting.*

e. *Vessels* (*tangential*) *with spirals.*

f. Heartwood pale yellow to whitish; *rays* (*tangential*) *all alike, uniseriate throughout, or nearly so,*
Aesculus hippocastanum.

ff. Heartwood brownish, reddish or dark red-brown; *rays* (*tangential*) *not all alike, 1-6-seriate.*

g. Pores (cross) abundant or fairly abundant, rather evenly distributed; growth rings (cross) not sinuous; pith flecks (cross) usually present; wood parenchyma (cross) not forming distinct, tangential markings.

h. Growth rings narrow; cross-section with curious, sinuous-mottled appearance; sapwood whitish,
Pyrus americana.

hh. Growth rings rather wide; cross-section without sinuous-mottled appearance; sapwood light brown,
Amelanchier canadensis.

gg. Pores (cross) not abundant, solitary-scattering or in remote, radial lines; growth rings (cross) sinuous; pith flecks (cross) usually absent; wood parenchyma (cross) forming distinct, tangential markings.

Ostrya virginiana.

ee. Vessels (tangential) without spirals.

f. Rays (tangential) all alike, ***uniseriate throughout or nearly so;*** wood for the most part soft and light.

g. Pores (cross) of summer wood markedly smaller and fewer in number than pores of spring wood, arranged in more or less prominent, wavy, concentric lines; wood (radial) without silky luster; ***rays (radial) with both upright and procumbent cells,***

Salix nigra.

gg. Pores (cross) of summer wood not markedly smaller and fewer in number than pores of spring wood, not arranged in more or less prominent, wavy concentric lines; wood (radial) with silky luster; ***rays (radial) with only procumbent cells*** ....**Populus,** p. 229.

ff. Rays (tangential) not all alike, but some broad, *1-6-seriate;* wood mostly hard and heavy.

g. Growth rings (cross) indistinct, very narrow and crowded together; *tyloses (longitudinal) present; larger rays (tangential) 1-2-, occasionally 3-seriate,*

Nyssa sylvatica.

gg. Growth rings (cross) distinct, not very narrow and not crowded together; *tyloses (longitudinal) absent; larger rays (tangential) 3-6-seriate.*

h. Rays (cross) just visible to the naked eye with close scrutiny; pores (cross) more or less uniformly distributed, neither larger nor more numerous in the spring wood; pith flecks (cross) rare or wanting; wood heavy and hard.

i. *Larger rays (tangential) 3-5-seriate;* pores (cross) visible to the naked eye with close scrutiny ....**Betula lenta.**

ii. *Larger rays (tangential) 1-2-, sometmes 3-seriate;* pores (cross) hardly visible to the naked eye with close scrutiny....**Betula lutea,** p. 227.

hh. Rays (cross) not visible to the naked eye with close scrutiny; pores (cross) not uniformly distributed, but somewhat larger and more numerous in the spring wood; pith flecks (cross) usually rather abundant; wood light and soft.

i. Pores (cross) of spring wood visible to the naked eye with close scrutiny; growth rings (cross) not marked by narrow, whitish, concentric lines; pith flecks (cross) usually small, not conspicuous,
Betula alba papyrifera.

ii. Pores (cross) of spring wood not visible to the naked eye with close scrutiny; growth rings (cross) marked by narrow, whitish, concentric lines, especially near the periphery; pith flecks (cross) usually large, conspicuous,
Betula populifolia.

aa. Pores (cross) not visible nor conspicuous, even with magnifier, *i. e., wood composed mostly of one kind of cells (tracheids), which are uniform in structure and arranged in definite radial rows;* resin ducts and resin cells (cross) often present, especially in the summer wood; rays (cross) never conspicuous.

b. Resin ducts or resin cells or both (cross) present, the former usually visible to the naked eye, the latter for the most part prominent and more or less confluent, forming conspicuous tangential lines; fusiform rays (tangential) present (absent in *Juniperus* and *Taxodium*).

c. Resin ducts and resin cells (cross) scattered, single or in groups, but never forming tangential lines; *fusiform rays (tangential) present; rays (radial) with tracheids.*

d. Heartwood distinct in color from sapwood; resin ducts (cross) conspicuous, because of size or color, *the epithelium cells thin-walled; fusiform rays (tangential) broad and prominent, usually with one to several large resin ducts.*

e. Resin ducts (cross) few, widely scattering, *without tyloses;* resin cells (cross) present near the outer limit of the summer wood; *tracheids (radial) with occasional spirals;* heartwood light russet-brown,
Larix laricina, p. 219.

ee. Resin ducts (cross) numerous, evenly scattered through the rings, *with prominent tyloses;* resin cells (cross) wholly absent; *tracheids (radial) wholly without spirals;* heartwood whitish, orange to reddish.

f. Transition (cross) from spring wood to summer wood gradual, the growth rings distinguished by narrow lines of darker colored summer wood; wood soft and light, slightly resinous; *lateral walls of ray cells* (*radial*) *of spring wood with 1-2 large pits to each tracheid.*

g. *Walls of ray tracheids* (*radial*) *smooth; pits* (*radial*) *on the tangential walls of the summer-wood cells numerous*.................. **Pinus strobus,** p. 215.

gg. *Walls of ray tracheids* (*radial*) *conspicuously toothed; pits* (*radial*) *on the tangential walls of the summer-wood cells absent,* **Pinus resinosa,** p. 217.

ff. Transition (cross) from spring wood to summer wood more or less abrupt, the growth rings distinguished by broad bands of darker colored summer wood; wood medium hard and heavy, strongly resinous; *lateral walls of ray cells* (*radial*) *of spring wood with 2-6 small pits to each tracheid.*

g. Growth rings (cross) wide, the resin ducts small, widely scattering; *fusiform rays* (*tangential*) *having the cells of the inflated portion all or mostly thick-walled, not broken out*............**Pinus banksiana.**

gg. Growth rings (cross) narrow, the resin ducts large, chiefly in the summer wood; *fusiform rays* (*tangential*) *having the cells of the inflated portion all or mostly thin-walled, all broken out,* **Pinus rigida.**

dd. Heartwood not distinct in color from the sapwood; resin ducts (cross) not conspicuous, of same color as surrounding wood; *fusiform rays* (*tangential*) *narrow, not prominent, with only one small resin duct.*

e. Growth rings (cross) wide; resin ducts (cross) rather numerous, *the epithelium cells thin-walled.*

f. Resin ducts (cross) scattered through both spring and summer wood, *with tyloses usually absent; pits* (*radial*) *on the tangential walls of the summer wood chiefly confined to the outermost tracheid wall,* **Picea canadensis.**

ff. Resin ducts (cross) confined chiefly to the summer wood, *with tyloses present; pits* (*radial*) *on the tangential walls of the summer wood not confined to the outermost wall, but usually numerous,* **Picea mariana.**

ee. Growth rings (cross) narrow; resin ducts (cross) not numerous, *the epithelium cells thick-walled,*

Picea rubra, p. 217.

cc. Resin ducts and resin cells (cross) not scattered, but more or less confluent and forming tangential lines; *fusiform rays (tangential) absent; rays (radial) chiefly or wholly without tracheids.*

d. Wood with odor like cedar oil, especially when wet; heartwood purplish to red-brown, with yellow-white sapwood, its smoothed surface dull; rings (cross) wavy and sinuous,

Juniperus virginiana.

dd. Wood odorless, even when wet; heartwood dull yellow- or gray-brown, differing only in shade from the sapwood, its smoothed surface greasy or waxy; rings (cross) regular, not wavy nor sinuous......**Taxodium distichum,** p. 223.

bb. Resin ducts (cross) absent and resin cells (cross), if present not prominent, not forming conspicuous, tangential lines; *fusiform rays (tangential) absent.*

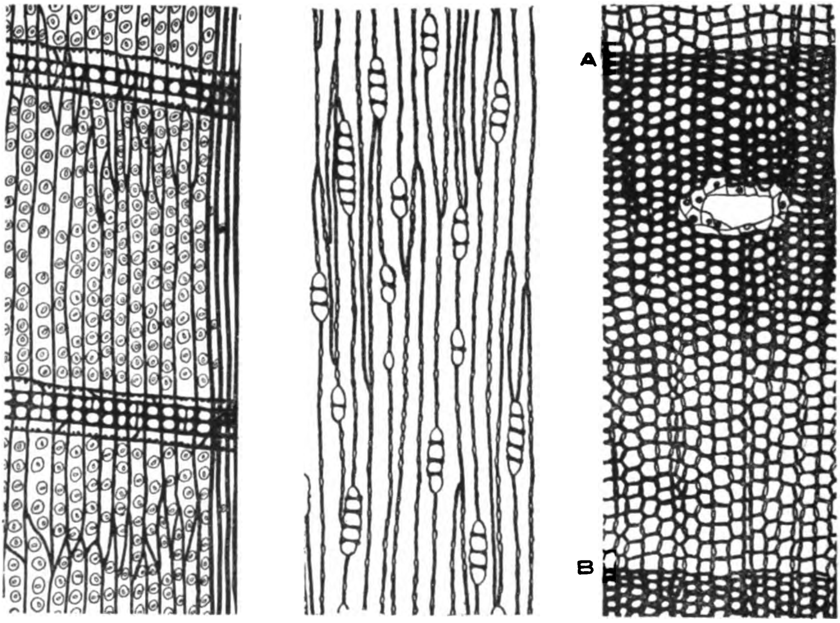
c. Wood with mild odor like cedar oil, especially when wet; heartwood distinct in shade from the sapwood; rings (cross) wavy; wood spongy, difficult to cut smoothly across the grain; *ray tracheids (radial) wholly absent,*

Thuja occidentalis, p. 221.

cc. Wood without odor of cedar oil, even when wet; heartwood not distinct in shade from the sapwood; rings (cross) not wavy; wood not spongy, easy to cut smoothly across the grain; *ray tracheids (radial) present.*

d. Transition (cross) from spring wood to summer wood abrupt; wood light red-brown, with rancid odor, especially when wet, cross-grained, splintery and hard to work; resin cells (cross) prominent, but not numerous; *ray tracheids (radial) prominent*............**Tsuga canadensis,** p. 219.

dd. Transition (cross) from spring wood to summer wood gradual; wood yellow-white to pale brown, odorless, even when wet, straight-grained, not splintery and easy to work; resin cells (cross) absent; *ray tracheids (radial) not prominent, occasional*..................**Abies balsamea,** p. 221.



RADIAL. TANGENTIAL. CROSS.

Sections of wood of Pinus resinosa, x 101.

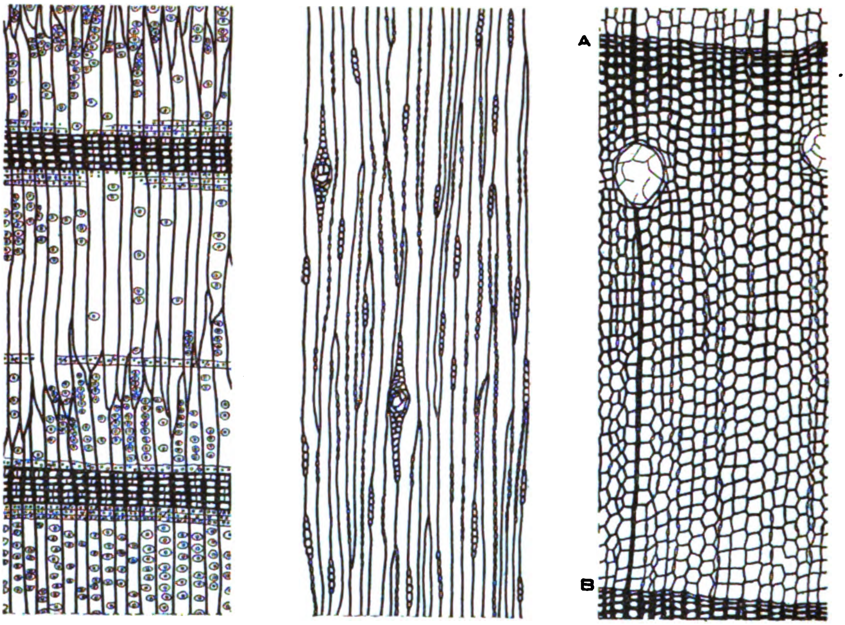
Red Pine. Norway Pine

Pinus resinosa Ait.

CHARACTERISTICS.—Bark thick, red-brown, shallowly fissured into broad, flat ridges; sapwood thin, yellow to white; heartwood pale red; non-porous; growth rings very wide and distinct; transition from spring wood to summer wood very gradual; rays numerous, faintly distinct, with fusiform rays few and these chiefly rather low and broad; resin ducts numerous, evenly scattered through the rings, with prominent tyloses; resin cells absent; tracheids without spirals.

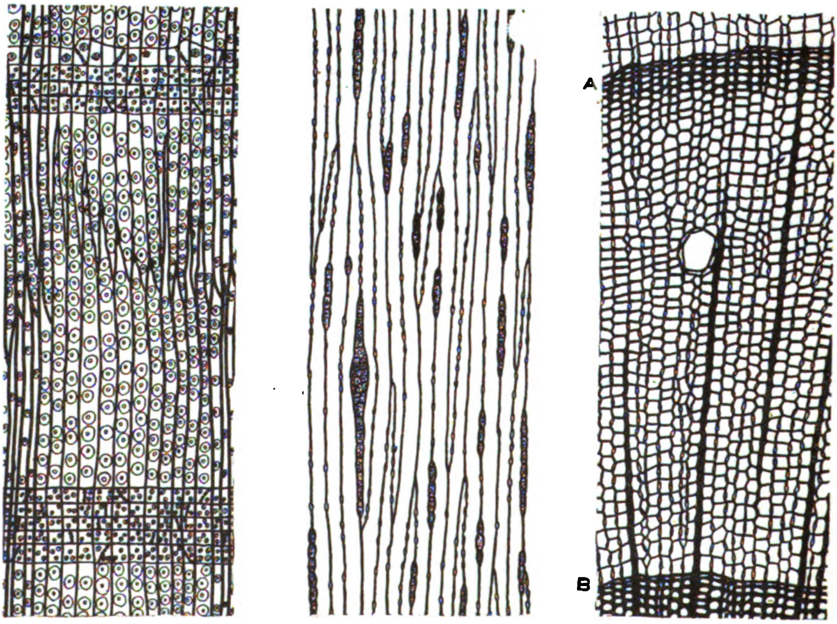
QUALITIES.—Rather light in weight, 31 pounds per cubic foot, seasoned; fairly soft; moderately strong; shrinkage 3 percent; warps moderately; not durable when exposed; straight- and very close-grained; easily worked; splits readily, but nails well.

USES.—Piles, flooring, sheathing, freight cars, poles, masts, etc.



RADIAL. TANGENTIAL. CROSS.

Sections of wood of Pinus strobus, x 40.



RADIAL. TANGENTIAL. CROSS.

Sections of wood of Picea rubra, x 97.

White Pine

Pinus strobus L.

CHARACTERISTICS.—Bark thick, dark gray, shallowly fissured into broad, scaly ridges; sapwood thin, whitish; heartwood clear yellow to light brown, turning red on exposure to the atmosphere; non-porous; growth rings wide, distinct; transition from spring wood to summer wood gradual; rays very faint, without resin ducts, the fusiform rays few; resin ducts (vertical) numerous, evenly scattered through the rings, with prominent tyloses; resin cells wholly absent; tracheids entirely without spirals.

QUALITIES.—Very light in weight, 27 pounds per cubic foot, seasoned; very soft; rather weak; shrinkage 3 percent; warps very little; moderately durable when exposed; very close- and straight-grained; easily worked; splits readily, but nails well.

USES.—Doors, window-sashes, interior finish and other carpentry, patterns, cabinet-work, matches, boxes, etc.; the most generally useful of all American woods.

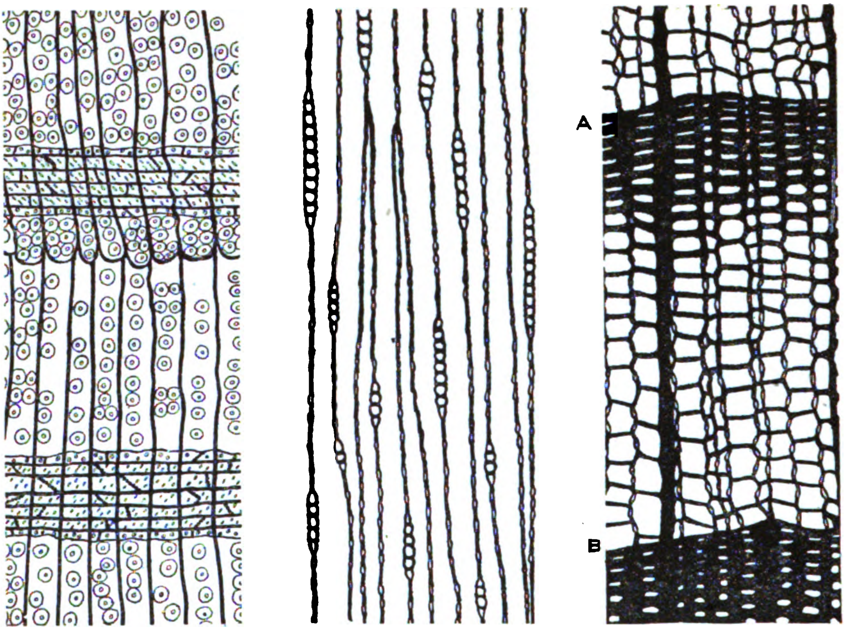
Red Spruce

Picea rubra (DuRoi) Dietr.

CHARACTERISTICS.—Bark red-brown, with thin, irregular scales; heartwood dull white, with occasional reddish streaks, with sapwood of nearly the same shade; non-porous; growth rings narrow, but distinct; transition from spring wood to summer wood gradual; rays very faint, the fusiform ones narrow; resin ducts few and small, scattered, without tyloses; resin cells absent; tracheids without spirals.

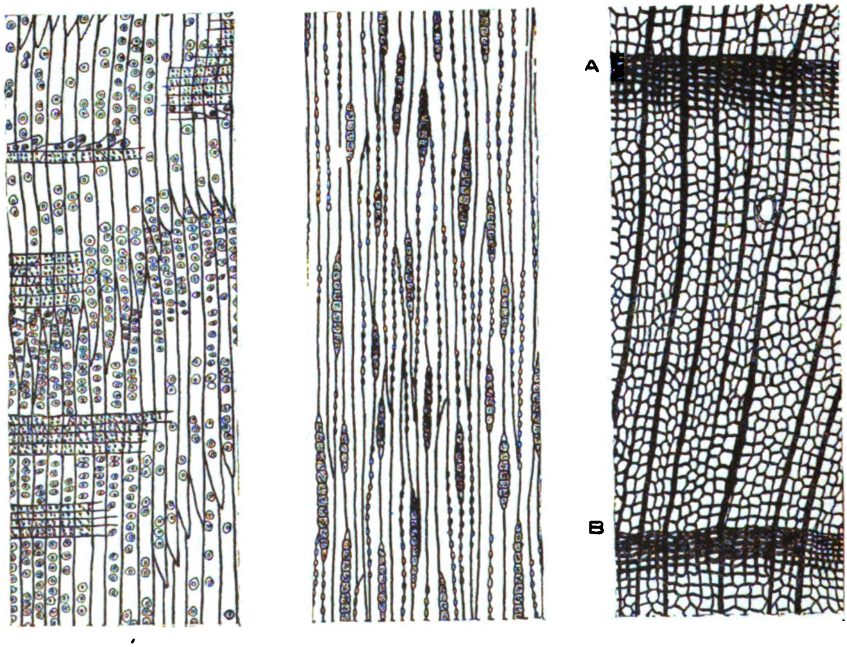
QUALITIES.—Rather light in weight, 28 pounds per cubic foot, seasoned; soft; fairly strong; shrinkage 3 percent; warps little; fairly durable when exposed; straight-grained; easy to plane and tolerably easy to saw, but hard to chisel neatly; splits easily in nailing.

USES.—Boats and canoes, oars and paddles, ship timbers, building construction, silos, sounding boards, paper pulp, ladders, etc.



RADIAL. TANGENTIAL. CROSS.

Sections of wood of Tsuga canadensis, x 90.



RADIAL. TANGENTIAL. CROSS.

Sections of wood of Larix laricina, x 65.

Hemlock

Tsuga canadensis (L.) Carr.

CHARACTERISTICS.—Bark thick, red-brown or grayish, deeply divided into narrow, rounded, scaly ridges; heartwood light red-brown, ill-smelling, with thin, darker colored sapwood; non-porous; growth rings rather wide, distinct; transition from spring wood to summer wood abrupt; rays numerous, obscure, none of them fusiform; resin ducts absent; resin cells few in number, but prominent; tracheids without spirals.

QUALITIES.—Rather light in weight, 26 pounds per cubic foot, seasoned; soft; fairly strong; shrinkage 3 percent; warps little; checks badly; not durable when exposed; coarse- and crooked-grained; difficult to work, because brittle and splintery; splits easily, but holds nails well.

USES.—Dimension materials, timbers, joints, rafters, plank walks, laths, etc.

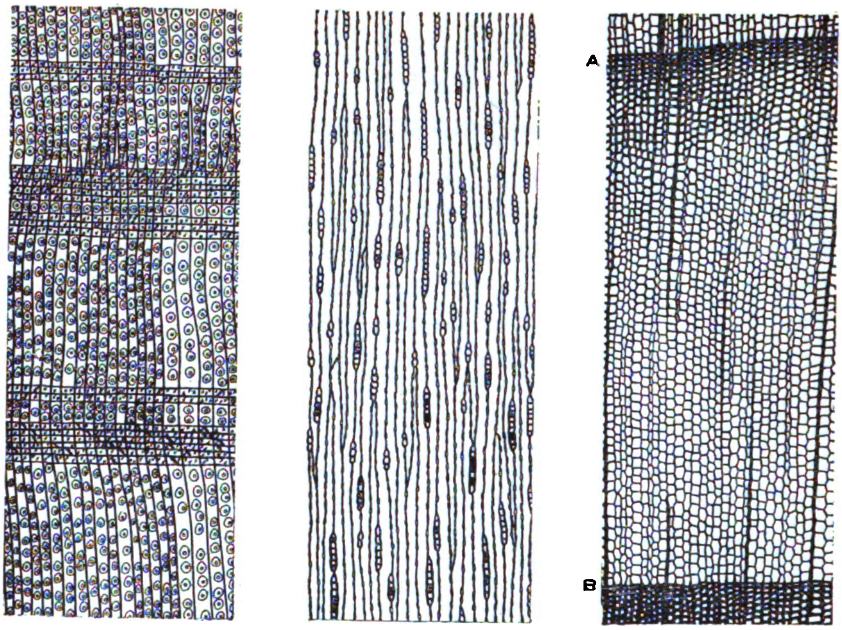
Tamarack

Larix laricina (DuRoi) Koch

CHARACTERISTICS.—Bark red-brown, scaly, without ridges; sapwood thin, nearly white; heartwood russet-brown; non-porous; growth rings rather broad and uniform, distinct; transition from spring wood to summer wood more or less abrupt; rays inconspicuous, many of them broadly fusiform, prominent and containing resin ducts; resin ducts (vertical) few, widely scattered, without tyloses; resin cells present near outer limit of summer wood; tracheids mostly without spirals.

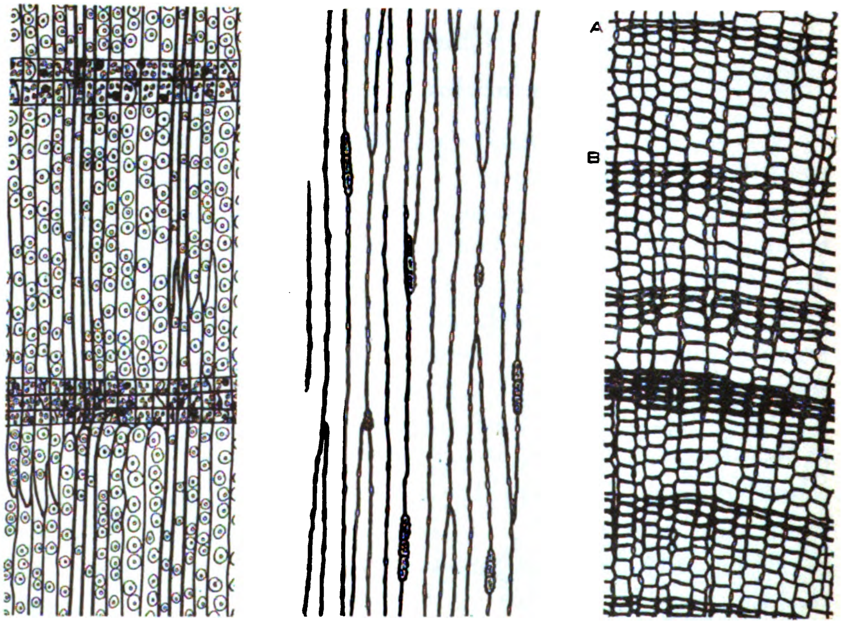
QUALITIES.—Weight medium, 39 pounds per cubic foot, seasoned; hardness medium; rather strong; shrinkage 3 percent; warps but little; rather coarse-grained; very durable in contact with the soil; easy to work; splits readily.

USES.—Ship and boat timbers, telegraph poles, fence posts, railroad ties, etc.



RADIAL. TANGENTIAL. CROSS.

Sections of wood of Abies balsamea, x 44.



RADIAL. TANGENTIAL. CROSS.

Sections of wood of Thuja occidentalis, x 139.

Balsam Fir

Abies balsamea (L.) Mill.

CHARACTERISTICS.—Bark pale gray-brown and marked by swollen resin chambers, or red-brown and roughened by small, scaly plates; sapwood thick, whitish; heartwood yellow-white to pale brown; non-porous; growth rings wide, indistinct; transition from spring wood to summer wood very gradual; rays inconspicuous, never fusiform and mostly without resin ducts; both resin ducts (vertical) and resin cells absent; tracheids without spirals.

QUALITIES.—Very light in weight, 23 pounds per cubic foot, seasoned; very soft; weak; shrinkage moderate; warps little; coarse-grained; perishable in contact with the soil; works easily; splits readily.

USES.—Cut, sold and used with spruce and pine, boxes, crates, packing cases, sheathing, etc.

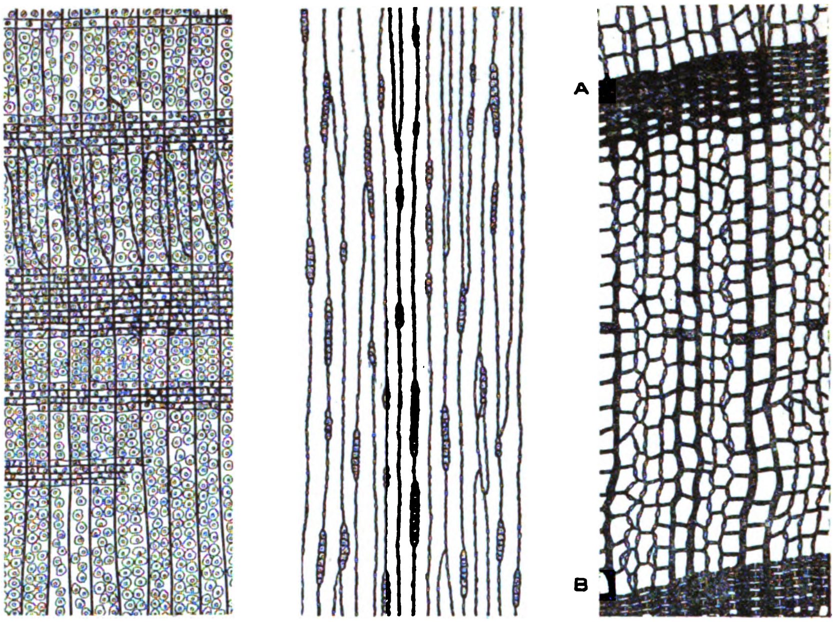
Arbor Vitae. White Cedar

Thuja occidentalis L.

CHARACTERISTICS.—Bark thin, light red-brown, slightly furrowed or deciduous in ragged strips; sapwood thin, whitish; heartwood pale yellow-brown; wood with mild odor like cedar oil; non-porous; growth rings narrow to wide, rather irregular and wavy, fairly distinct by the narrow, but denser summer wood; transition from spring wood to summer wood more or less abrupt; rays very faint, microscopic; resin ducts absent and resin cells few and usually widely scattering; tracheids wholly without spirals.

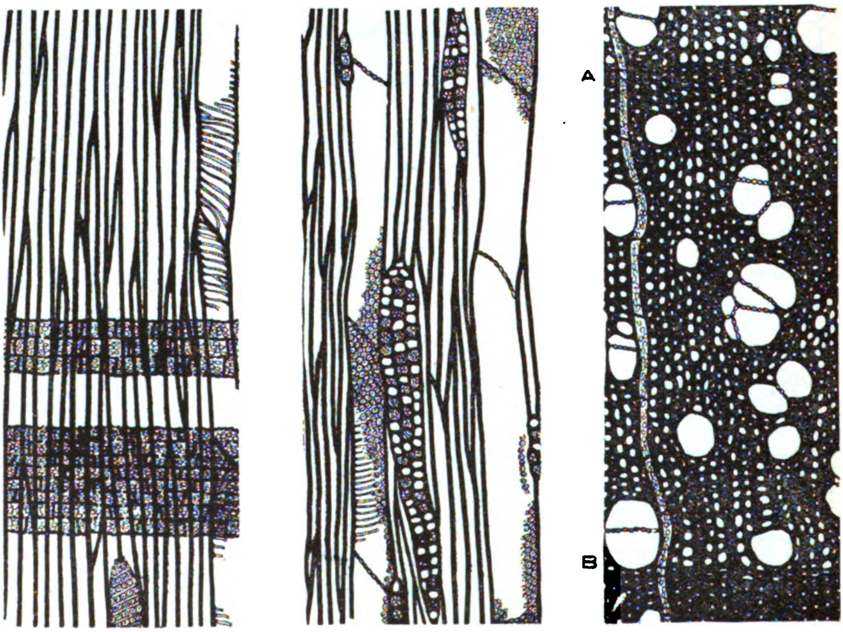
QUALITIES.—Very light in weight, 19 pounds per cubic foot, seasoned; very soft; very weak; shrinks and checks but little; warps little; rather coarse-grained; brittle; very durable in contact with the soil; easily worked; splits easily, but nails well.

USES.—Posts, railroad ties, shingles, etc.



RADIAL. TANGENTIAL. CROSS.

Sections of wood of Taxodium distichum, x 47.



RADIAL. TANGENTIAL. CROSS.

Sections of wood of Acer saccharum, x 127.

Bald Cypress. Cypress[1]

Taxodium distichum (L.) Richard

CHARACTERISTICS.—Bark light red, shallowly fissured into broad, flat plates and peeling into fibrous strips; sapwood thin, nearly white; heartwood dull yellow- or gray-brown or sometimes blackish; non-porous; growth rings usually very broad and well-marked by the dense and conspicuous summer wood; transition from spring wood to summer wood somewhat gradual; rays very obscure, none of them fusiform; resin ducts absent; resin cells numerous, large, more or less confluent and forming tangential lines on the cross-section; tracheids wholly without spirals.

QUALITIES.—Fairly light in weight, 29 pounds per cubic foot, seasoned; soft; rather weak; shrinkage 3 percent; warps but little, although liable to check; close-grained; very durable in contact with the soil; easy to work; nails well; frequently "peggy" or "pecky" from a fungous disease.

USES.—Shingles, posts, interior finish, boats, cooperage, greenhouse construction, etc.

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[1] Not native to Vermont, but included here because of its widespread use.

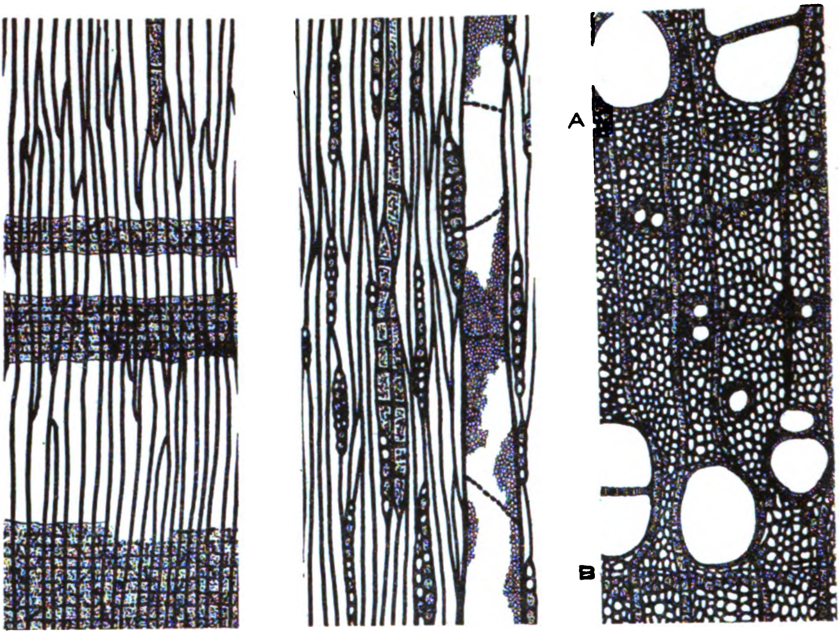
Sugar Maple. Rock Maple

Acer saccharum Marsh.

CHARACTERISTICS.—Bark dark gray and deeply furrowed, often cleaving up at one edge in long, thick plates; sapwood thin, lighter colored than the light brown heartwood; diffuse-porous; growth rings narrow, but distinct; pores somewhat uniform in size, not crowded, inconspicuous; rays fine, but distinct; vessels with spirals.

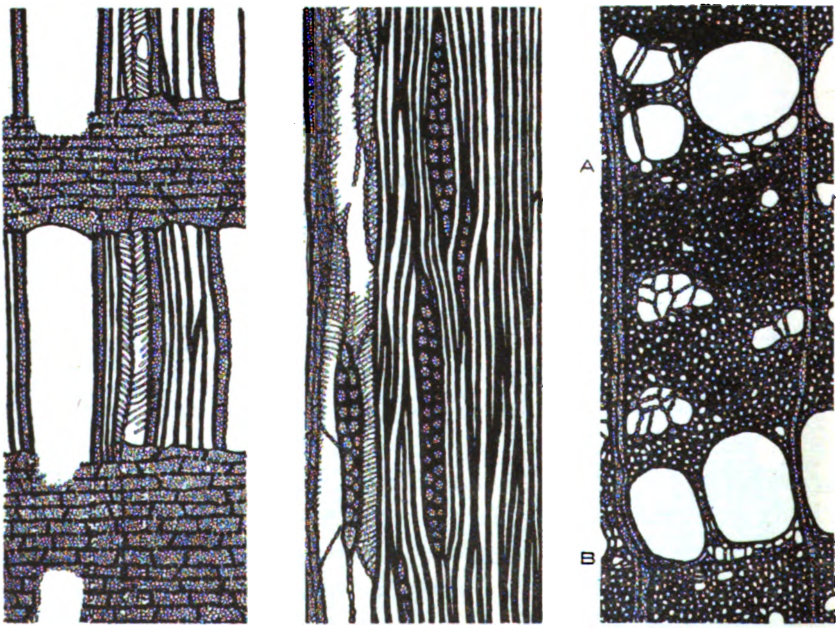
QUALITIES.—Heavy, 43 pounds per cubic foot, seasoned; very hard; very strong; shrinkage 5 percent; warps badly; close-grained, but the fibers sometimes twisted, waved or curly, producing "bird's eye" and "curly" effects; not durable when exposed; wears evenly; splits badly in nailing; hard to work.

USES.—Flooring, fuel, furniture, wagon-stock, carving, tool-handles, etc.



RADIAL. TANGENTIAL. CROSS.

Sections of wood of Fraxinus americana, x 92.



RADIAL. TANGENTIAL. CROSS.

Sections of wood of Ulmus americana, x 138.

White Ash

Fraxinus americana L.

CHARACTERISTICS.—Bark gray, deeply furrowed into firm, narrow, flattened ridges; sapwood thick, whitish; heartwood brownish; ring-porous; growth rings rather narrow, distinctly marked by 3-5 rows of large pores in the spring wood; pores of the summer wood small and inconspicuous, joined by wood parenchyma to form short, broken, tangential lines, especially near the periphery of the growth ring; rays inconspicuous to microscopic; vessels without spirals.

QUALITIES.—Fairly heavy, 39 pounds per cubic foot, seasoned; rather hard; fairly strong; shrinkage 5 percent; warps little; straight- and close-grained; not durable in contact with the soil; splits readily and nails badly; becomes brittle with age.

USES.—Farm implements, oars, handles, interior finish, cheap cabinet-work, carriage-stock, etc.

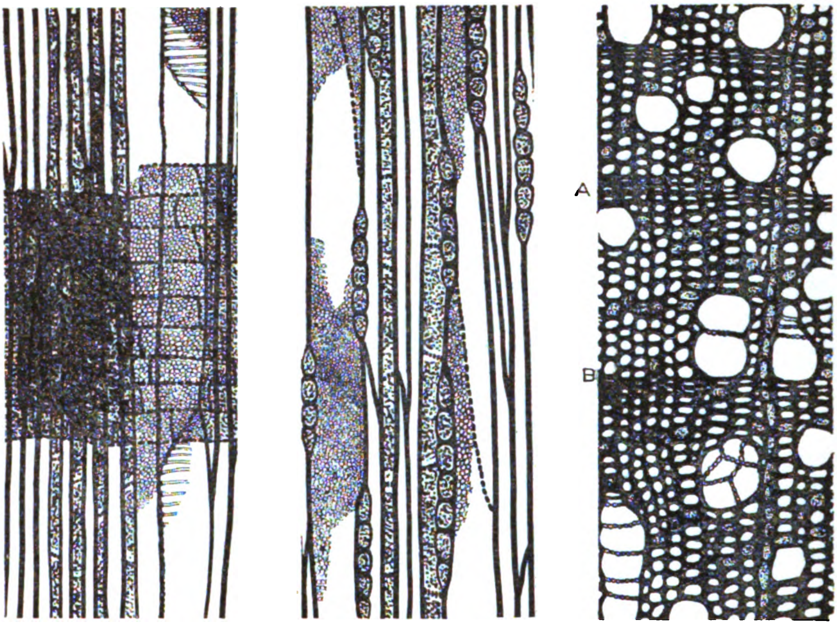
American Elm. White Elm

Ulmus americana L.

CHARACTERISTICS.—Bark ash-gray, deeply fissured into broad, scaly ridges; sapwood thick, yellowish; heartwood light brown; ring-porous; growth rings rather wide, distinctly marked by usually one row of large pores in the spring wood; pores of summer wood somewhat smaller, forming broad, mostly connected, tangential lines, which are strongly wavy; rays numerous, inconspicuous; vessels with spirals.

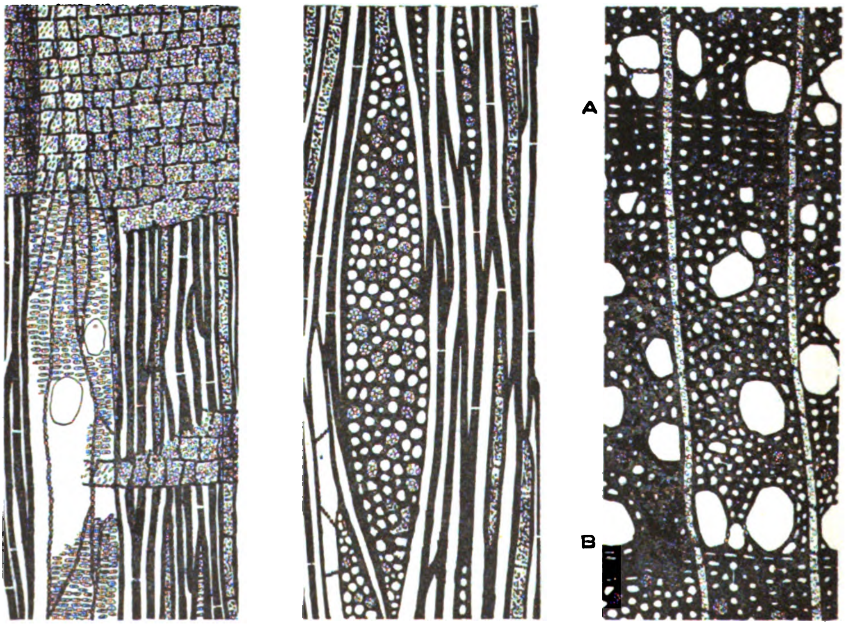
QUALITIES.—Fairly heavy, 34 pounds per cubic foot, seasoned; hardness medium; fairly strong; shrinkage 5 percent; warps and checks considerably; coarse-grained, with the fibers commonly interlaced; not durable in contact with the soil; difficult to split; tough and hard to work.

USES.—Wheel-stock, cooperage, heavy timbers, heavy agricultural implements, etc.



RADIAL. TANGENTIAL. CROSS.

Sections of wood of Betula lutea, x 163.



RADIAL. TANGENTIAL. CROSS.

Sections of wood of Fagus grandifolia, x 156.

Yellow Birch. Gray Birch

Betula lutea Michx. f.

CHARACTERISTICS.—Bark silvery yellow-gray and breaking into strips more or less curled at the edges or blackish and deeply and irregularly fissured into large, thin plates; sapwood thin, whitish; heartwood light brown tinged with red; diffuse-porous; growth rings fairly distinct; pores more or less uniform in size, not crowded, inconspicuous; rays numerous, indistinct; vessels without spirals.

QUALITIES.—Heavy, 40 pounds per cubic foot, seasoned; moderately hard; very strong; shrinkage 6 percent; warps little; close-grained and compact; not durable when exposed; difficult to split and holds nails well; rather hard to work, but polishes well.

USES.—Furniture, spools, flooring, shoe lasts and pegs, handles, etc.

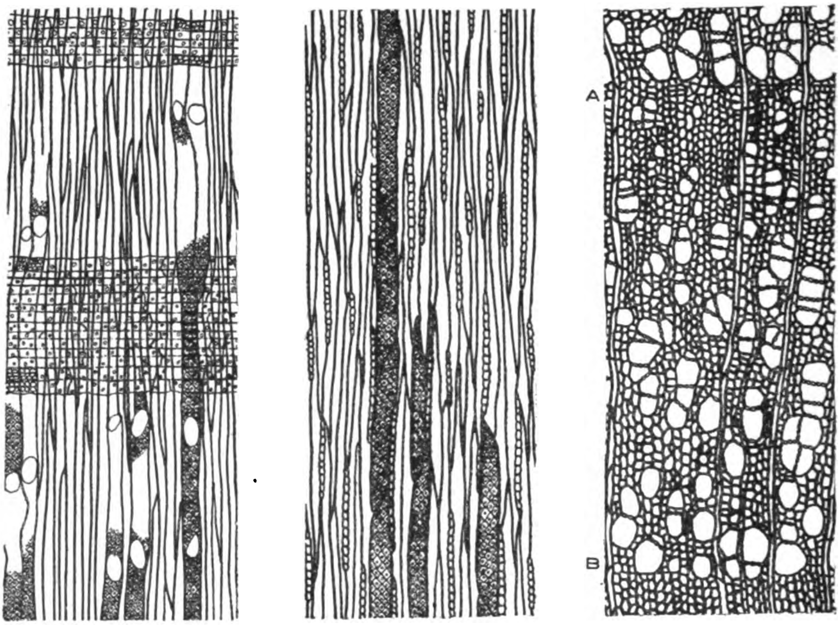
Beech

Fagus grandifolia Ehrh.

CHARACTERISTICS.—Bark close, smooth, steel-gray, often mottled by darker blotches and bands; sapwood thin, whitish; heartwood light or dark red; diffuse-porous; growth rings obscure; pores largest in spring wood, gradually diminishing in size toward outer limit of summer wood; rays of two kinds, partly very broad and partly very narrow; vessels without spirals.

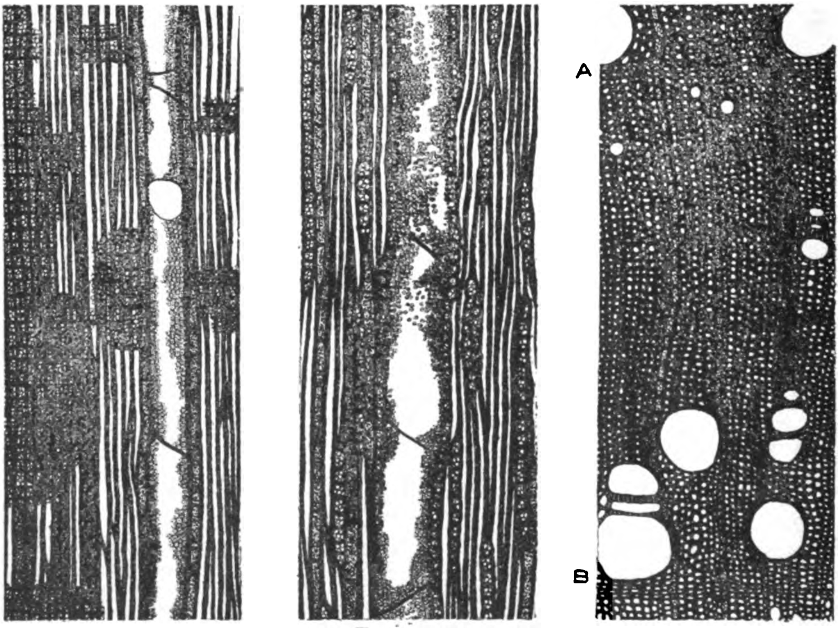
QUALITIES.—Heavy, 42 pounds per cubic foot, seasoned; rather hard; strong; shrinkage 5 percent; warps and checks during seasoning; straight- and very close-grained; not durable when exposed; moderately difficult to split; tough; hard to work; difficult to nail.

USES.—Ship timbers, flooring, tool-handles, furniture, fuel, etc.



RADIAL. TANGENTIAL. CROSS.

Sections of wood of Populus tremuloides, x 80.



RADIAL. TANGENTIAL. CROSS.

Sections of wood of Carya ovata, x 100.

American Aspen. Trembling Poplar. Popple

Populus tremuloides Michx.

CHARACTERISTICS.—Bark thin, yellowish or greenish and smooth, often roughened with darker, horizontal bands or wart-like excrescences; sapwood thin, whitish; heartwood light brown; diffuse-porous; growth rings very wide, not well-defined; pores more or less uniform in size, but rather more crowded in the spring wood; rays very fine and indistinct; vessels without spirals.

QUALITIES.—Very light, 25 pounds per cubic foot, seasoned; soft; weak; shrinks moderately; warps considerably to excessively, but checks little; close-grained; not durable when exposed; works easily.

USES.—Paper pulp, boxes, crates, excelsior, woodenware, etc.

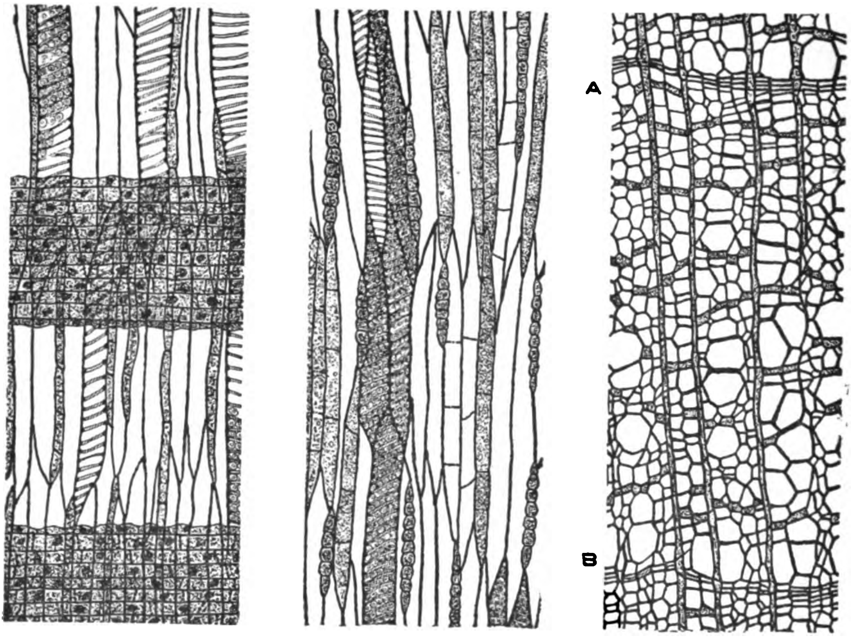
Shellbark Hickory

Carya ovata (Mill.) K. Koch

CHARACTERISTICS.—Bark thick and grayish, separating into thick strips 1-3 feet long, free at one or both ends, giving the log a shaggy appearance; sapwood thin, whitish; heartwood light brown; ring-porous; growth rings narrow, but distinctly marked by the one or more rows of relatively large pores in the spring wood; pores of the summer wood small and inconspicuous; rays numerous, but inconspicuous to microscopic; wood parenchyma forming more or less continuous, tangential lines as distinct, or nearly so, as the rays; vessels without spirals, but containing tyloses.

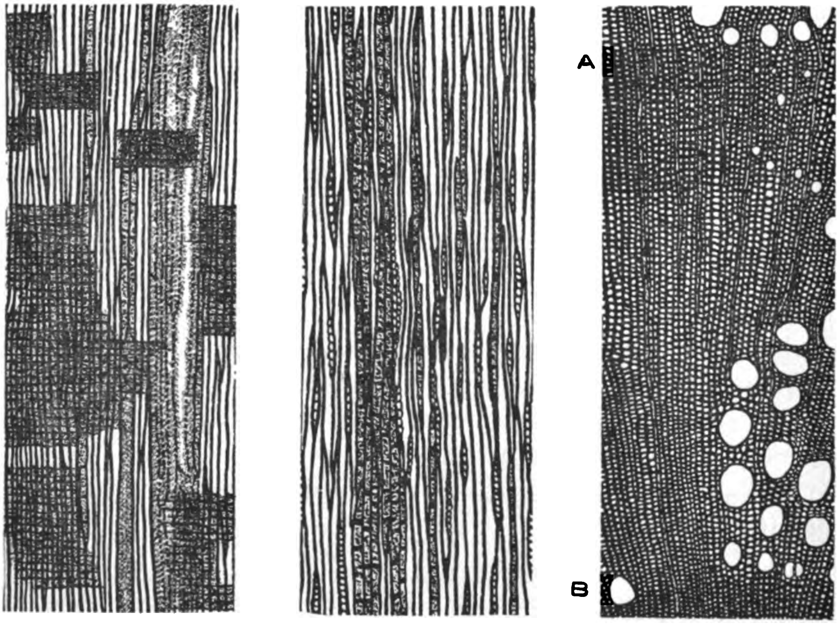
QUALITIES.—Very heavy, 51 pounds per cubic foot, seasoned; very hard; very strong; shrinkage 10 percent; warps badly; straight- and close-grained; not durable when exposed; hard to split and very difficult to nail; very tough and hard to work.

USES.—Agricultural implements, handles, carriage-stock, sled runners, fuel, etc.



Radial. Tangential. Cross.

Sections of wood of Tilia americana, x 112.



Radial. Tangential. Cross.

Sections of wood of Quercus rubra, x 64.

Basswood

Tilia americana L.

CHARACTERISTICS.—Bark thick, dark gray or brownish, deeply furrowed into broad, scaly ridges; inner bark fibrous and tough; sapwood thick, light red-brown, hardly distinguishable from the heartwood; diffuse-porous; growth rings rather narrow, but distinct; pores all the same sizes or nearly so, rather evenly distributed; rays numerous, obscure; wood-parenchyma cells forming continuous or somewhat broken, tangential lines or bands, alternating with wood elements in a tier-like arrangement; vessels with spirals.

QUALITIES.—Light in weight, 28 pounds per cubic foot, seasoned; very soft; very weak; shrinkage 6 percent; very straight- and close-grained; warps comparatively little; not durable in contact with the soil; somewhat tough to split and nails well; very easily worked.

USES.—Carriage and wagon bodies; woodenware, boxes, toys, numerous small articles, etc.

Red Oak

Quercus rubra L.

CHARACTERISTICS.—Bark gray-brown, smooth or shallowly fissured into thin, firm, broad ridges; inner bark light red; sapwood thin, darker than the light red-brown heartwood; ring-porous; growth rings rather wide, distinctly marked by several rows of very large pores in the spring wood; pores of summer wood arranged in radial, branching lines, diminishing in size toward outer limits of the summer wood; wood parenchyma grouped irregularly around the pores; rays few, but mostly broad and conspicuous; vessels without spirals.

QUALITIES.—Rather heavy, 45 pounds per cubic foot, seasoned; fairly hard; rather strong; shrinkage 6-10 percent; warps and checks badly; coarse-grained; moderately durable in contact with the soil; splits readily and nails badly.

USES.—Furniture, interior finish, cooperage, agricultural implements, fuel, etc.

A LIST OF VERMONT WOODS ARRANGED IN THE ORDER OF THEIR WEIGHT FROM HEAVY TO LIGHT

1. Carya ovata
2. Carya alba
3. Carya glabra
4. Betula lenta
5. Quercus alba
6. Quercus macrocarpa
7. Carpinus caroliniana
8. Ulmus racemosa
9. Quercus velutina
10. Acer saccharum
11. Fagus grandifolia
12. Betula lutea
13. Fraxinus americana
14. Quercus rubra
15. Ulmus americana
16. Fraxinus nigra
17. Fraxinus pennsylvanica
18. Larix laricina
19. Acer rubrum
20. Betula alba papyrifera
21. Prunus serotina
22. Platanus occidentalis
23. Acer saccharinum
24. Juniperus virginiana
25. Pinus resinosa
26. Picea mariana, Picea rubra
27. [1]Taxodium distichum
28. Tilia americana
29. Salix nigra
30. Tsuga canadensis
31. Liriodendron tulipifera
32. Juglans cinerea
33. Picea canadensis
34. Pinus strobus
35. Populus tremuloides
36. Abies balsamea
37. Thuja occidentalis

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[1] Not native to Vermont.

GLOSSARY

WITH PAGE REFERENCES TO EXPLANATORY FIGURES

Abortive. Defective or barren.
Achene. A small, dry, one-seeded fruit in which the ovary wall adheres to the seed.
Acorn. The fruit of the oak.
Acuminate. Gradually tapering to the apex. Page 7.
Acute. Terminating with a sharp angle. Page 7.
Alternate. Said of leaves, branches, buds, etc., scattered singly along the stem; not opposite.
Androgynous. Composed of both staminate and pistillate flowers.
Anterior. The front side of a flower, remote from the axis of inflorescence.
Anther. The part of a stamen which bears the pollen. Page 8.
Apetalous. Without petals.
Apex. The top, as the tip of a bud or the end of a leaf which is opposite the petiole.
Apiculate. Ending in a short-pointed tip.
Appressed. Lying close and flat against.
Arborescent. Attaining the size or character of a tree.
Aromatic. Fragrant; with an agreeable odor.
Axil. The upper one of the two angles formed by the juncture of a leaf with a stem.
Axillary. Situated in an axil.

Bark. The outer covering of a trunk or branch. Page 195.
Bearded. Bearing a long, bristle-like appendage, or furnished with long or stiff hairs.
Berry. A fruit which is fleshy throughout.
Bipinnate. Twice pinnate.
Blade. The expanded portion of a leaf, etc.
Bloom. A powdery or waxy substance easily rubbed off.
Bract. A more or less modified leaf subtending a flower or belonging to an inflorescence.
Branch. A secondary division of a trunk.
Branchlet. A small branch.
Bud. An undeveloped stem or branch, with or without scales.
Bud-scales. Modified leaves covering a bud.
Bundle-scars. Dots on the surface of a leaf-scar, which are scars left by the fibro-vascular bundles which run through the petiole into the blade of the leaf. Page 10.
Bur. A spiny fruit.

Calyx. The outer part of a perianth, usually green in color. Page 8.
Cambium. The ring or zone of tender, growing cells between the bark and the wood.
Campanulate. Bell-shaped.
Capsule. A dry fruit of more than one carpel which splits at maturity to release the seeds.
Carpel. A simple pistil, or one member of a compound pistil.
Catkin. A spike of unisexual flowers, each subtended by a bract, and usually deciduous in one piece.
Cell. One of the minute units or elements, of very various forms, of which plants are formed. Page 195.
Cellulose. The fundamental substance of the cell-wall.
Chambered. Said of pith which is interrupted by hollow spaces.
Ciliate. Fringed with hairs on the margin.
Cinereous. Ash-gray color.
Claw. The narrow, stalk-like base of a petal, sepal, etc.
Cleft. Cut about half-way to the middle.
Cluster. A group of two or more organs (flowers, fruit, etc.) on a plant at a node or end of a stem.
Columnar. Having the form of a column.
Compound. Composed of two or more similar parts united into a whole.
Compound leaf, one divided into separate leaflets.
Compressed. Flattened laterally.

Concentric. One within another, with a common center.
Cone. A fruit with woody, overlapping scales.
Confluent. Blended or flowing into one; passing by degrees one into the other.
Conical. Cone-shaped, largest at the base and tapering to the apex.
Conifer. A tree of the pine family, so called from its bearing cones.
Coniferous. Cone-bearing; of, or pertaining to, the pine family.
Connective. The portion of a stamen which connects the two cells of the anther.
Cordate. Heart-shaped. Page 7.
Coriaceous. Leather-like in texture.
Corky. Made of, or like cork.
Corolla. The inner part of a perianth, usually bright colored. Page 8.
Corrugated. Wrinkled or in folds.
Corymb. A flower-cluster in which the axis is shortened and the pedicels of the lower flowers lengthened, forming a flat-topped inflorescence, the marginal flowers blooming first. Page 9.
Corymbose. Arranged in corymbs.
Crenate. Dentate, with the teeth much rounded. Page 8.
Crenulate. Finely crenate.
Cross-grained. Having the grain gnarled and hard to cut.
Cross-section. A section of a body at right angles to its length. Page 195, d.
Crown. The upper part of a tree, including the living branches with their foliage.
Cutting. A piece of stem, root or leaf which, if cut off and placed in contact with the soil, will form new roots and buds, reproducing the parent plant.
Cyme. A broad and flattish inflorescence, the central flowers of which bloom first. Page 9.
Cymose. Arranged in cymes.

Deciduous. Not persistent; falling away, as the leaves of a tree in autumn.
Decurrent. Said of a leaf which extends down the stem below the point of fastening.
Decussate. Alternating in pairs at right angles.
Dehiscent. Opening by valves or slits.
Deltoid. Delta-shaped; triangular.
Dentate. Toothed, with the teeth usually pointed and directed outward. Page 8.
Depressed. Somewhat flattened from above.
Dichotomous. Branching regularly in pairs.
Diffuse-porous. Said of wood whose pores are nearly uniform in size and more or less evenly diffused through both spring and summer wood.
Digitate. Said of a compound leaf in which the leaflets are borne at the apex of the petiole; finger-shaped.
Dioecious. Unisexual, with staminate and pistillate flowers on different individuals.
Distribution. The geographical extent and limits of a species.
Divergent. Said of buds, cones, etc., which point away from the twig, or of pine needles, etc., which spread apart.
Dormant. A term applied to parts which are not in active life.
Dorsal. Pertaining to the back or outer surface of an organ.
Downy. Covered with fine hairs.
Drupe. A fleshy or pulpy fruit in which the inner portion is hard or stony.
Duct. See resin duct.

Ellipsoid. An elliptical solid.
Elliptical. Oval or oblong with regularly rounded ends. Page 7.
Emarginate. Notched at the apex. Page 7.
Entire. Without divisions, lobes or teeth.
Epithelium. The somewhat modified parenchyma lining certain intercellular cavities, as the resin ducts.
Epithelium cell. A cell of the epithelium.
Escape. Any plant formerly cultivated that grows wild in fields.
Excrescences. Warty outgrowths or protuberances.
Exfoliate. To cleave off, as of the outer layers of bark.

Falcate. Scythe-shaped.
Fascicle. A compact cluster of leaves or flowers.
Fascicled. Arranged in fascicles.
Fastigiate. Said of branches which are erect and near together.
Feather-veined. Having veins extending from the midrib to the margin, feather-wise.
Fertile. Capable of bearing fruit.
Fertilization. The mingling of the contents of a male (pollen) and female (ovule) cell.
Fibro-vascular bundles. The strands that make up the framework of higher plants.
Filament. The part of a stamen which bears the anther. Page 8.
Filamentose or *Filamentous.* Composed of threads or filaments.
Flaky. With loose scales easily rubbed off (bark).
Fleshy. Succulent; juicy.
Flower. An axis bearing stamens or pistils or both (calyx and corolla usually accompany these). Page 8.
Fluted. With rounded ridges.
Fruit. The part of a plant which bears the seed.
Fungous. Relating to the *Fungi*, i. e., plant organisms of a lower order destitute of chlorophyll.
Fusiform. Thick, but tapering towards each end. *Fusiform ray*, a medullary ray which is fusiform in cross-section.

Germinate. To sprout, as of a seed.
Gibbous. Swollen on one side.
Glabrous. Neither rough, pubescent, nor hairy; smooth.
Gland. Secreting surface or structure; a protuberance having the appearance of such an organ.
Glandular. Bearing glands.
Glaucous. Covered or whitened with a bloom.
Globose. Spherical or nearly so.
Globular. Nearly globose.
Graining. The fibrous arrangement of the particles in wood, determining its hardness, splitting qualities, smoothness, etc.
Gregarious. Growing in groups or colonies.
Growth ring. An annual ring of growth. Page 195, VIII, h.

Habit. The general appearance of a plant, best seen from a distance.
Habitat. The place where a plant naturally grows, as in water, clay soil, marsh, etc.
Hairy. With long hairs.
Halberd-shaped. Like an arrow-head, but with the basal lobes pointing outward nearly at right angles. Page 7.
Heartwood. The dead central portion of the trunk or large branch of a tree. Page 195, VIII, c.
Hirsute. Covered with rather coarse or stiff hairs.
Hoary. Gray-white with a fine, close pubescence.
Homogeneous. Uniform; composed of similar parts or elements.
Hybrid. A cross between two nearly related species, formed by the action of the pollen of one upon the pistil of the other, yielding an intermediate form.
Hybridize. Forming a cross-breed of two species.

Imbricate. Overlapping, like the shingles on a roof.
Indehiscent. Not opening by valves or slits; remaining persistently closed.
Indigenous. Native and original to a region.
Inflorescence. The flowering part of a plant, and especially its arrangement.
Interlaced. Twisted or linked into each other.
Internode. The portion of a stem between two nodes.
Involucral. Pertaining to an involucre.
Involucre. A circle of bracts surrounding a flower or cluster of flowers.

Keeled. With a central ridge like the keel of a boat.
Key-fruit. An indehiscent winged fruit found in maples and ashes.

Laciniate. Cut into narrow, pointed lobes.
Lanceolate. Lance-shaped, broadest above the base and tapering to the apex, but several times longer than wide. Page 7.
Lateral. Situated on the side of a branch.
Leaf. The green expansions borne by the branches of a tree, consisting of a blade with or without a petiole.
Leaflet. One of the small blades of a compound leaf.
Leaf-scar. The scar left on a twig by the falling of a leaf. Page 10, c.
Legume. A pod-like fruit composed of a solitary carpel and usually splitting open by both sutures (*Leguminosae*).
Lenticels. Corky growths on young bark which admit air to the interior of a twig or branch.
Linear. Long and narrow, with parallel edges (as pine needles). Page 7.
Loam. A non-coherent mixture of sand, clay and organic matter.
Loamy. Of the nature of or like loam.
Lobe. Any division of an organ, especially if rounded.
Lobed. Provided with a lobe or lobes. Page 8.
Luster. Brilliancy or sheen; gloss.
Lustrous. Glossy; shining.

Medullary rays. Plates of cellular tissue radiating from the pith to the bark. They are primary when they extend from pith to bark and secondary when they are of less extent than the primary. Page 195, i.
Membranaceous. Thin and somewhat translucent.
Midrib. The central vein of a leaf or leaflet.
Monoecious. Unisexual, with staminate and pistillate flowers on the same individual.
Mucilaginous. Slimy; resembling or secreting mucilage or gum.
Mucronate. Tipped with a small, abrupt point. Page 7.

Naked. Lacking organs or parts which are normally present in related species or genera.
Naturalized. Said of introduced plants which are reproducing by self-sown seeds.
Nectariferous. Producing nectar.
Node. The place upon a stem which normally bears a leaf or whorl of leaves.
Non-porous. Said of wood whose structure is homogeneous, without large pores.
Nut. A hard and indehiscent, 1-celled, 1-seeded fruit.
Nutlet. A diminutive nut.

Oblanceolate. Lanceolate, with the broadest part toward the apex. Page 7.
Oblique. Slanting, or with unequal sides.
Oblong. Longer than broad, with sides approximately parallel. Page 7.
Obovate. Ovate, with the broadest part toward the apex. Page 7.
Obovoid. An ovate solid with the broadest part toward the apex.
Obtuse. Blunt or rounded at the apex. Page 7.
Opaque. Dull; neither shining nor translucent.
Opposite. Said of leaves, branches, buds, etc., on opposite sides of a stem at a node.
Orbicular. Circular. Page 7.
Oval. Broadly elliptical. Page 7.
Ovary. The part of a pistil that contains the ovules. Page 8.
Ovate. Egg-shaped, with the broad end basal. Page 7.
Ovoid. Solid ovate or solid oval.
Ovule. The part of a flower which after fertilization becomes the seed.

Palmate. Radiately lobed or divided; hand-shaped.
Panicle. A loose, irregularly compound inflorescence with pedicellate flowers. Page 9.
Paniculate. Arranged in panicles or resembling a panicle.
Papilionaceous. Butterfly-like, as in flowers of the *Leguminosae.*
Parenchyma. The soft, thin-walled, cellular tissue of plants. Page 195, IX, e.
Parenchyma elements. The cells or units composing the parenchyma.
Pedicel. The stalk of a single flower in a compound inflorescence.

Pedicellate. Borne on a pedicel.

Peduncle. A primary flower-stalk, supporting either a cluster or a solitary flower.

Pendent. Hanging downward.

Pendulous. More or less hanging or declined.

Perfect. Said of a flower with both stamens and pistil. Page 8.

Perianth. The calyx and corolla of a flower considered as a whole.

Periphery. Circumference.

Persistent. Long-continuous, as leaves through the winter, calyx on the fruit, etc.

Petal. One of the divisions of a corolla. Page 8.

Petiolate. Having a petiole.

Petiole. The stem or stalk of a leaf.

Petiolulate. Having a petiolule.

Petiolule. The stem or stalk of a leaflet.

Pilose. Hairy with long, soft hairs.

Pinnate. Compound, with the leaflets arranged along both sides of a common petiole.

Pistil. The seed-bearing organ of a flower, normally consisting of ovary, style and stigma. Page 8.

Pistillate. Provided with a pistil, but usually without stamens.

Pit. A small hollow or depression, as in a cell-wall. Page 195, IX, a.

Pith. The softer central part of a twig or stem. Page 195, VIII, g.

Pith flecks. Dark marks in timber due to the cavities made by the larvae of certain insects working in the cambium.

Pod. A dry and many-seeded, dehiscent fruit.

Pollen. The fecundating grains borne in the anther.

Polygamo-dioecious. Sometimes perfect, sometimes unisexual, both forms borne on different individuals.

Polygamo-monoecious. Sometimes perfect, sometimes unisexual, both forms borne on the same individual.

Polygamous. Sometimes perfect, sometimes unisexual, both forms borne on the same or on different individuals.

Pome. A fleshy fruit, as the apple.

Pore. Any small aperture; a name given to the large vessels or tracheids in hard woods.

Porous. Having large pores visible to the naked eye. See ring-porous and diffuse-porous.

Posterior. The back side of a flower, next to the axis of inflorescence.

Prickle. A small spine growing from the bark.

Procumbent. Lying flat, with the long axis in a horizontal direction.

Protoplasm. The living matter of cells, into which all nourishment is taken and from which all parts are formed.

Puberulent. Minutely pubescent.

Puberulous. Minutely pubescent.

Pubescence. A covering of short, soft hairs.

Pubescent. Covered with short, soft hairs.

Punctate. Dotted with translucent or colored dots or pits.

Raceme. A simple inflorescence of flowers on pedicels of equal length arranged on a common, elongated axis (rachis). Page 9.

Racemose. Resembling a raceme.

Rachis. The central axis of a spike or raceme of flowers or of a compound leaf.

Radial. Radiating, as from a center, i. e., as from the pith.

Radial-section. A longitudinal-section of a body which passes through its center, as the pith of a twig or log. Page 195, VIII, e.

Ray. I. e., medullary ray.

Ray cell. A cell of the medullary ray.

Ray tracheid. A tracheid found in the medullary rays of some trees.

Recurved. Curved downward or backward.

Resin cell. A cell which secretes resin.

Resin duct. A canal or opening between cells containing fluid resin.

Reticulate. Netted.

Rhombic. Equilateral, with the angles oblique.

Ring. Meaning growth ring.

Ring-porous. Said of wood whose large pores are collected into a row or band in each growth ring.

Rough. Harsh to the touch; pubescent.

Rugose. Wrinkled.

Samara. An indehiscent winged fruit.

Sapwood. The living outer portion of a trunk or large branch of a tree between the heartwood and the bark. Page 195, VIII, b.

Scalariform. Having markings suggestive of a ladder.

Scales. Small modified leaves, usually thin and scarious, seen in buds and cones; the flakes into which the outer bark often divides.

Scaly. Provided with scales.

Scar. See leaf-scar.

Scarious. Thin, dry, membranaceous; not green.

Scurfy. Covered with small bran-like scales.

Seed. The ripened ovule.

Sepal. One of the divisions of a calyx. Page 8.

Seriate. Disposed in series or rows.

Serrate. Toothed, the teeth sharp and pointing forward. Page 8.

Sessile. Without a stalk.

Sheath. A thin enveloping part as of a leaf, any body enwrapping a stem.

Shrinkage. A contraction of any material, as wood, into less bulk or dimensions.

Shrub. A bushy, woody growth, usually branched at or near the base, less than 15 feet in height.

Silhouette. A drawing having its outline filled in with uniform color, commonly black.

Simple. Of one piece; not compound.

Sinuate. Strongly wavy. Page 8.

Sinuous. In form like the path of a snake.

Sinus. The cleft or space between two lobes.

Smooth. Smooth to the touch; not pubescent.

Spatulate. Wide and rounded at the apex, but gradually narrowed downward. Page 7.

Sphagnous. Resembling or allied to the genus *Sphagnum*, a moss.

Spike. A simple inflorescence of sessile flowers arranged on a common, elongated axis (rachis). Page 9.

Spine. A sharp woody outgrowth from a stem.

Spirally. As though wound in a spiral around an axis.

Spirals. A term applied to the spiral thickenings of tracheids and vessels. Page 195, IX, c.

Spontaneous. Self-planted or generated; wild or sporadic; growing without human agency.

Spray. The aggregate of smaller branches and branchlets.

Spring wood. The wood produced early in the growing season, characterized by larger ducts and cells and thinner walls than the later growths possess; the inner portion of each annual increment.

Spur. A hollow sac-like or tubular extension of some part of a blossom.

Stamen. The pollen-bearing organ of a flower, normally consisting of filament and anther. Page 8.

Staminate. Provided with stamens, but usually without pistils.

Staminodium. A sterile stamen.

Sterile. Unproductive, as a flower without pistil, or a stamen without anther.

Stigma. The part of a pistil which receives the pollen. Page 8.

Stipules. Leaf-like appendages on either side of a leaf at the base of the petiole.

Stipule-scar. The scar left by the fall of a stipule. Page 10.

Striate. Marked with fine longitudinal stripes or ridges.

Strobile. A cone.

Style. The part of a pistil connecting ovary with stigma. Page 8.

Sub-. A prefix applied to many botanical terms, indicating somewhat or slightly.

Subtend. To lie under or opposite to.

Sucker. A shoot arising from a subterranean part of a plant.

Summer wood. The wood produced late in the growing season, characterized by smaller ducts and cells and thicker walls than the earlier growths possess; the outer portion of each annual increment.
Superposed. Placed above, as one bud above another at a node.
Suture. A junction or line of dehiscence.

Tangential. At right angles to the medullary rays.
Tangentially. In a tangential manner.
Tangential-section. A longitudinal-section of a body at right angles to any one of its radii; any longitudinal-section of a tree trunk which does not pass through the pith. Page 195, VIII, f.
Terete. Circular in cross-section.
Terminal. Situated at the end of a branch.
Ternate. In threes.
Tetrahedral. Having, or made up of, four faces (triangles).
Texture. The disposition, arrangement or character presented by the different elements in the structure of the wood.
Thorn. A stiff, woody, sharp-pointed projection.
Thyrse. A contracted or ovoid and usually compact panicle.
Tissue. The texture or material built up by the union of cells of similar origin and character.
Tolerant. Capable of enduring more or less heavy shade.
Tomentose. Densely pubescent with matted wool.
Toothed. With teeth or short projections.
Torus. The part of the axis of a flower which bears the floral organs.
Trachea. A duct or vessel. Page 195, IX, b.
Tracheid. A long, slender cell, with closed ends and its walls thickened after the cell has attained its full size. Page 195, IX, a.
Transition. Change as from spring wood to summer wood.
Transverse. Said of a wood section made at right angles with the axis of the stem; across the grain.
Tree. Usually defined as a plant with a woody stem, unbranched at or near the base, reaching a height of at least 15 feet.
Trunk. The main stem of a tree.
Turbinate. Top-shaped.
Tylosis. A growth, frequently exhibiting repeated cell-division, intruding within the cavity of a duct or vessel from the wall of a contiguous growing cell.

Umbel. A simple inflorescence of flowers on pedicels which radiate from the same point. Page 9.
Umbellate. Arranged in umbels.
Undulate. With a wavy margin or surface. Page 8.
Uniseriate. In one horizontal row or series.
Unisexual. Of one sex, either staminate or pistillate; not perfect.

Veins. Threads of fibro-vascular tissue in a leaf, petal, or other flat organ.
Vessel. A duct or jointed tube which becomes continuous by the more or less complete absorption of the intervening cross-walls. Page 195, IX, b.
Villose or *Villous.* Covered with long, soft hairs.
Viscid. Glutinous; sticky.

Warp. To become uneven in outline, as by shrinkage; to become twisted or distorted out of shape.
Whorl. An arrangement of leaves or branches in a circle round an axis.
Wing. Any membranous or thin expansion bordering or surrounding an organ.
Wood. The hard part of a stem lying between the pith and the bark.
Wood elements. The cells or units making up the wood.
Wood fibers. Long, slender cells with thick walls and narrow cavities, which impart strength and toughness to the wood and bark. Page 195, IX, d.
Wood parenchyma. A several-celled fiber in which the end cells have pointed extremities while the intermediate cells have square ends. Page 195, IX, e.
Woolly. Covered with long and matted or tangled hairs.

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MARCH, 1916 BULLETIN 195

University of Vermont and State Agricultural College

Vermont Agricultural Experiment Station

BURLINGTON, VERMONT

STUDIES OF THE VALUES OF DIFFERENT GRADES OF MILK IN INFANT FEEDING

by

R. M. WASHBURN and C. H. JONES

1791

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BULLETIN 197: COMMERCIAL FEEDING STUFFS

By J. L. Hills, C. H. Jones and G. F. Anderson

CONCERNING THE OAT CROP

By J. L. Hills

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I. SUMMARY

More than 700 samples representing over 400 different brands of feeding stuffs were analyzed in the 1916 inspection. The results were distinctly disappointing—the worst in years. They may be summarized as follows:

If we may judge of the entire trade by the samples drawn by the Station—and there is no other criterion by which to judge—

1. Half of the cottonseed meal sold last fall, winter and spring in Vermont were not what they were represented to be in respect to their protein contents.
2. One-fifth of the distillers' dried grains was similarly deficient.
3. A third of the brewers' dried grains was similarly deficient.
4. One out of six of the wheat feeds was similarly deficient.
5. One out of five proprietary stock feeds was similarly deficient.

Speaking broadly, Vermonters during the past feeding season have been paying more for poorer goods than at any time during the last twenty years.

What can they do about it? Little or nothing except to watch the bulletin statements and do what they can to buy brands which seem likely—in view of their past history—to be as good as they are said to be, provided their promises are adequate. It would, of course, be farcical to buy a low grade goods at a high price because the guaranty was maintained instead of a high graded brand at a medium or, indeed, high price because it was not quite as good as it was said to be. In other words, guaranty maintenance is but one of several factors which should be borne in mind in determining the choice of feed. However, as between two brands of the same class and same guarantied protein content, other things being equal, farmers would do well to buy the brand whose record is lily white rather than one whose past history is blemished by exaggerated guaranty claims. The statements on pages 13 to 45, alphabetically arranged by manufacturers' or jobbers' names within classes, will enable anyone readily to determine the facts concerning any feeding stuff as developed in the past season's inspection.

II. INTRODUCTION

The sampling agents of the Station visited 68 towns and villages in Vermont in late December, 1915, and early January, 1916, and in March and April, 1916, and drew 719 samples from dealers' stocks, representing over 400 brands of goods which either are subject to or exempt from the necessity of guaranty. The entire state was fairly well covered except Essex County. The larger wholesale and many retail places were visited twice, but points remote from the railroad were not often reached. All of these samples were examined chemically for protein. Both guarantied and unguarantied goods were analyzed; the former to determine so far as might be learned their purity, as well as the maintenance of the standards fixed by the manufacturers; the latter to determine, if possible, whether as a matter of fact the goods were pure and, hence, not subject to guaranty.

Only the protein contents of the samples were determined.

The reader who may be interested in the economics of feed purchase is referred to matter on pages 34 to 44 of bulletin 144, as well as to that on pages 582 to 590 of bulletin 152. Full descriptions of the nature and manufacture of the various goods offered on the Vermont market will be found on pages 22 to 34 of bulletin 144, together with a discussion of the advisability or inadvisability of their purchase, as the matter appealed to the writer when the bulletin was written.

SYNOPSIS OF THE PUBLIC STATUTES DEALING WITH FEEDING STUFFS

The essentials of the Vermont feeding stuff law are as follows:

Sections 4983-4. *Definition of the term "concentrated commercial feeding stuff";* including the common feeds other than hay, straw, whole seeds and unmixed meals, wheat, rye and buckwheat offals.

Section 4985. *Statement of contents;* net weight, brand name and address of manufacturer, minimum percentages of crude protein and crude fat, maximum percentage of crude fiber, and the specific name of each ingredient used in manufacture.

Section 4986. *Illegal sales; penalty.* The omission of the guaranty, a material overstatement of the actual protein or fat contents or understatement of the actual fiber contents, and the omission of or incorrect statement of the specific name of each ingredient are forbidden; fine, not to exceed fifty dollars for the first or one hundred dollars for each subsequent offense.

Section 4987. *Adulterations; exceptions; penalty.* The adulteration of whole or ground grain, or of bran, middlings or mixed feed with offals, unless the fact is stated on each package, and the inclusion of more than two percent by weight of weed seeds unless stated on each package, are forbidden; fine, not less than twenty-five dollars nor more than one hundred dollars.

Section 4988. *Appropriation; expenses; report.* Five hundred dollars annual appropriation; annual financial statement to be published by the Station.

Section 4989. *Prosecutions.* Notice to dealer giving thirty days time wherein to comply with law; failing which, report is made to state's attorney; no prosecution in relation to quality if the same is substantially equivalent to the guaranty.

Section 4990. *Collection of samples.* Authorization to enter and take samples; not less than five percent of entire lot to be sampled, thoroughly mixed, sealed and labelled; samples to be taken in duplicate if requested by the dealer.

Section 4991. *Analyses of samples; publication.* One sample of each brand to be analyzed; results, together with additional information in relation to the character, composition, value and use of feeding stuffs, shall be published.

Section 4992. *Exception.* Act does not apply to persons purchasing feeding stuffs for their own use and not for sale.

Section 4993. *Obstructing director; penalty.* Provision against hindrance in execution of law.

On the whole the law is well observed at present. In a few cases, particularly when mixtures are locally made in a small way by Vermont dealers, the packages do not declare their contents in terms of ingredients as is now required by law. Unguarantied goods are infrequent at the present time and overguaranties are not as common as once they were; but overstatements in advertising still occur. The law cannot control extravagant statements in the press or elsewhere. It is for the buyers to look askance thereat and to ask the Station as to the facts.

It is not generally appreciated that there is a federal law which aids in preventing misbranding, misstatement and adulteration of such goods as may enter into interstate commerce. The state law, of course, cannot hold outside of state lines; but serious cases of fraud may be reported to federal authorities. In this way local dealers who sell in good faith need not be troubled to any great extent and the parties actually responsible for illegal sales may be reached.

It is but just, both to the consumer and to the Station, to say in this connection that the inspection of commercial feeding stuffs in Vermont is extremely inadequate; that in comparison with that done in other states it is almost pitiable in its inability to meet the real needs of the buyer. This is not the fault of the Station, which does what it can with a very small appropriation, many times smaller, it is believed, than that which is available in any other state. It should be remarked in this connection, however, that in view of the fact that police duties of this character are not the essential function—indeed, strictly speaking, not a proper function—of an experiment station but are excrescences, it is not a situation which causes its administration any worriment. The Station neither desires nor intends to campaign for increased appropriations in the interests of a more thorough inspection of the trade in commercial feeding stuffs; nor does it mean to agitate towards that end. It simply seeks thus to set forth in self-defence the reason why its work is relatively ineffective.

REVISED METHOD OF STATEMENT OF ANALYTICAL RESULTS

The system of statement of analyses hitherto in use has not proved satisfactory. The results have not been set forth in as clear fashion as might be desired, they have been in many instances located on different pages, and the meaning of the analytical figures, though few in number, were not always apprehended by bulletin readers. Hence another system has been employed in this bulletin, whereby for each feeding stuff there are shown in a single paragraph:

1. The name and address of the manufacturer.
2. The name and address—or names and addresses—of the local dealer or dealers from whose stocks the samples were drawn.
3. The brand name.
4. The "specific name of each ingredient used in (the) manufacture" of the feeding stuff, in case it is a compounded material, as stated by the manufacturers upon bag or tag.
5. The percentage of crude protein guaranteed by the manufacturers to be present.
6. The accuracy of the manufacturer's protein guaranty, stated not in terms of figures but in terms of words:—using the phrase "guaranty fulfilled" if as a matter of fact the goods contained as much protein as they were said to contain, or the phrase "but failed by— percent to fulfill guaranty" if as a matter of fact the goods did not contain as much crude protein as they were said to contain.

Within classes, the order of arrangement is alphabetical by manufacturers' names, following the system now used in fertilizer and seed inspection bulletins. Makers' names are printed in small capitals; brand names and guaranties are printed in italics.

This system groups within a single paragraph all the information which the Station is able to purvey concerning a given sample. Not all that might be given to advantage, not all that is usually given in the feeding stuffs inspection bulletins of other states, but all that can be furnished in view of the meagre appropriation. No attempt is made to show the fat and crude fiber guaranties, since it is impossible for the Station to assert whether or not they are accurate. They are shown on each package and a would-be buyer can readily determine for himself what they are in any given case. In several cases more than one sample, either single or composite, was analyzed. This means usually that samples were drawn both in the midwinter and in the early spring sampling trips; the samples for the one being analyzed in January, and for the other in April.

A further advantage derived from a method of statement which does not indicate to what extent, if any, a protein guaranty is exceeded is that occasionally the analytical data are misleading to the purchaser. A given sample may be very high in protein, far in excess of its guaranty, in a certain inspection, due to some slip in formula making or otherwise; and buyers may be thus mislead. Notwithstanding the fact that some samples may carry higher protein contents then their guaranties indicate, it is always safe to assume the manufacturer's promise as a basis of purchase, except in cases where the station bulletin shows that guaranties are not maintained. That is all that one can safely go by; that is all the law is meant to do, to make it as certain as may be that manufacturers' promises mean what they say; that they "state what they sell and sell what they state," neither more nor less.

From the standpoint of the enforcement of the law, the important matter is simply this: do the goods contain what they are said to contain.

Concerning the phraseology in tabular matter, in cases where guaranties are not made good, it should be said that in cases where the deviation was but a fraction of a percent, no stress should be laid upon the shortage, unless it be that the crude protein guaranty is a low one, say 12 percent or less. Of course a one-half percent deficiency in a goods guarantied to contain but 10 percent protein is equivalent to a shortage of $\frac{1}{20}$ or 5 percent, whereas a similar lack in a cottonseed meal, guarantied to carry 41 percent, would be but 1/82 or but little more than 1 percent of the promised amount.

Concerning the phraseology used by some manufacturers in naming the "specific ingredients" it may be said that the Standard Dictionary defines an "ingredient" to be "that which is placed in or specifically enters into the constitution of any mixture or compound, or is a component part of any conglomerate; component; part; as, the ingredients of gunpowder are niter, charcoal and sulphur." Now "clipped oat by-products," "oat feed," etc., are not ingredients, but combinations of ingredients, just as gunpowder is not an ingredient but a combination of ingredients; hence labels carrying such statements are considered to be illegal and are so designated in the tabular matter.

STANDARDS: AVERAGE COMPOSITION

A standard is defined to be "a measure of quality established by law or by general usage or consent; any type, model, example or authority with which comparison may be made; any fact, thing or circumstance forming a basis for adjustment and regulation." Now standards, i. e., "measures of quality," "examples with which comparison may be made," are of service in connection with the use of feeding stuffs. Thus one is able the better to pass judgment on the worth of a given sample. The percentages of protein, fat and fiber form in part the basis of judgment in this connection. If a given sample is of good appearance, neither moldy, rancid nor in other ways spoiled, is mechanically in good condition, is free from objectionable foreign matter and carries approximately the protein and fat percentages and not materially more than the fiber content shown below, it is probably safe to assume it to be of standard quality.

The following table of averages indicates closely the average composition of the goods more commonly sold in Vermont.

	Protein	Fat	Fiber
I. GOODS CARRYING MORE THAN 30 PERCENT PROTEIN			
Cottonseed meal (choice)	41.	9.5	7.
Cottonseed meal (prime and good)	36.	8.	8.
Linseed meal (new process)	36.8	2.8	9.
Linseed meal (old process)	34.1	7.6	9.
Distillers' dried grains (first grade)	31.6	13.1	12.
II. GOODS CARRYING 25 TO 30 PERCENT PROTEIN			
Buckwheat middlings	29.1	7.5	5.
Distillers' dried grains (second grade)	27.5	11.5	13.
Brewers' dried grains	26.1	7.1	12.
Malt sprouts	26.5	1.5	12.5

	Protein	Fat	Fiber
III. GOODS CARRYING 20 TO 25 PERCENT PROTEIN			
Gluten feeds	23.7	3.	7.5
IV. GOODS CARRYING 15 TO 20 PERCENT PROTEIN			
Molasses feeds (as a class) exclusive of horse feeds	16.2	3.4	12.
Wheat middlings	17.1	5.1	5.
Wheat mixed feed	16.2	4.8	9.
Wheat bran	15.2	4.7	10.
V. GOODS CARRYING 10 TO 15 PERCENT PROTEIN			
Molasses feeds for horses (as a class)	12.4	3.3	15.
Fortified oat feeds	12.9	3.8	8.
Alfalfa meals	13.1	1.3	28.
Hominy meal	10.5	8.4	4.5
Ground oats	10.6	4.8	10.
VI. GOODS CARRYING 5 TO 10 PERCENT PROTEIN			
Corn and oat feeds (as a class)	9.2	5.1	9.
Provender	9.2	4.3	6.
Oat feeds (as a class)	6.8	3.1	20.
Corn meal	8.9	3.4	2.
Dried beet pulp	8.	0.3	18.
VII. POULTRY FEEDS			
Meat scraps	50.	15.	..
Meat and bone meals	40.	10.	..
Mashes	16.	4.	7.
Chick feed	12.	3.	3.
Scratch feed	11.	3.	3.

DEFINITIONS[1] OF FEEDING STUFFS AND "INGREDIENTS"

The feeding stuffs law, as amended by the General Assembly of 1912, requires that "the specific name of each ingredient used in its manufacture" be stated on "each lot or parcel of concentrated commercial feeding stuff." Manufacturers have not in all cases complied with this feature of the law.

Cottonseed meals, linseed meals, gluten feeds, distillers' dried grains, brewers' dried grains, malt sprouts, dried beet pulp, hominy feed, ground beef or fish scraps, all of them "concentrated commercial feeding stuffs" as defined in Section 4983 P. S., if true to name and not sold under some trade name not indicative of their true nature, are not held to be compounded materials and, hence, no special statement as to "ingredients" need appear on the package.

Cottonseed feeds, molasses feeds, oat feeds, corn and oat feeds, proprietary mixtures and mixed feeds (not wheat mixed feeds free from adulteration or from wheat screenings), condimental stock and poultry foods, and stock feeds, must now carry on each package a statement of their ingredients. Lack of funds prevents any careful survey of the samples to determine whether or not as a matter of fact the statements of ingredients made by the manufacturer are accurate. On account of its lack of information the Station expresses no opinion as to whether in any given case manufacturers' statements in this respect are or are not reliable. However, it knows of no reason to allege inaccuracy in any case. The manufacturers' statements occur on pages 29 to 40.

Cottonseed meal is a product of the cottonseed only, composed principally of the kernel with such portion of the hull as is necessary in the manufacture of oil; provided that nothing shall be recognized as cottonseed meal that does not conform to the foregoing definition and that does not contain at least 36 percent of protein.

Choice cottonseed meal must be finely ground, not necessary bolted, perfectly sound and sweet in odor, yellow, free from excess of lint, and must contain at least 41 percent of protein.

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[1] In the main those adopted by the Association of Official Feed Analysts.

Prime cottonseed meal must be finely ground, not necessarily bolted, of sweet odor, reasonably bright in color, yellow, not brown or reddish, free from excess of lint, and must contain at least 38.6 percent protein.

Good cottonseed meal must be finely ground, not necessarily bolted, of sweet odor, reasonably bright in color, and must contain at least 36 percent protein.

Linseed meal is the ground residue after extraction of part of the oil from ground flaxseed. The "old process" meal is made from crushed flaxseed which has been heated and subjected to hydraulic pressure; the "new process" meal is made from crushed flaxseed which has been extracted after heating by repeated leachings with light naphtha, all traces of which are removed by steam treatment. The latter goods carry but half the fat content of the former and usually from one to two percent more protein.

Corn starch byproduct with corn bran (the entire coating of the corn kernel) is that portion of commercial shelled corn that remains after the separation of the larger part of the starch and the germ by the processes employed in the manufacture of corn starch and glucose. It may or may not contain corn solubles.

Gluten feed is a product obtained in the manufacture of starch and glucose from corn and is a mixture of gluten meal, corn bran, germ residues, and, permissibly, "steep water" residues. It consists largely of the flinty portion of the outer coatings of kernel, being essentially the corn grain with its starchy portion largely removed.

Distillers' dried grains are the dried residue from cereals obtained in the manufacture of alcohol and distilled liquors. The product shall bear the designation of the cereal predominating.

Brewers' dried grains are the properly dried residue from cereals obtained in the manufacture of beer.

Proprietary feeds are admixtures made by manufacturers of a greater or less number of feeding stuffs, high grade, low grade or both. A statement of the ingredients, but not the proportions or "formula," must be declared upon each package.

Hominy meal, hominy feed, or hominy chop is a mixture of the bran coating, the germ and a part of the starchy portion of the corn kernel obtained in the manufacture of hominy grits for human consumption.

Corn and oat feeds are proprietary mixtures into the compounding of which enter considerable quantities of oat by-products as well as corn. They usually carry less than 12 percent protein and from 8 percent upwards of crude fiber. "Chop" is a ground or chop feed composed of one or more different cereals or the by-products therefrom.

Alfalfa meal is the entire alfalfa hay ground, and does not contain an admixture of ground alfalfa straw or other foreign materials.

Dried beet pulp is the dried sugar beet residue obtained in the manufacture of beet sugar, with or without an admixture of beet molasses.

Calf meals are proprietary feeds intended as whole or partial substitutes for milk in the feeding of young calves.

Meat scrap and meat meal are the ground residues from animal tissue exclusive of hoof and bone. If they contain any considerable amount of bone, they must be designated meal and bone scrap, or meat and bone meal. If they bear a name descriptive of their kind, composition or origin, they must correspond thereto.

Rye feeds are by-products obtained in the manufacture of rye flour.

III. RESULTS OF INSPECTION

The following statements touching the results of the inspection cover the entire lot of samples drawn during the past winter and spring. They do not include the multitudinous samples sent in by local dealers. The results are listed in the order as shown in the table of contents, page 3, and occur on pages 13 to 40.

COTTONSEED MEALS

F. W. BRODÉ & Co., Memphis Tenn. Chas. M. Seaver, Williamstown; H. S. Buttles' Estate, Brandon; Richmond & Son, Northfield; J. D. Thompson, Norwich; J. G. Turnbull & Co., Orleans; Swerdferger & Davis, Marshfield. *Owl.* Guaranteed to contain *41* percent crude protein but failed by 3¼ percent to fulfill guaranty (winter sampling).

F. W. BRODÉ & Co., Memphis Tenn. W. C. Ballou, Newfane; S. P. Curtis & Son, Rutland; Kempton Mills, Barre; A. H. McLeod Milling Co., St. Johnsbury; H. Parker, North Troy. *Owl.* Guaranteed to contain *41* percent crude protein, but failed by 5 percent to fulfill guaranty (spring sampling).

F. W. BRODÉ & Co., Memphis, Tenn. L. L. Marsh, Enosburg Falls. *Dove.* Guaranteed to contain *38.63* percent crude protein; guaranty fulfilled.

BUCKEYE COTTON OIL Co., Cincinnati, O. E. W. Bailey & Co., Montpelier; A. H. McLeod Milling Co., St. Johnsbury; E. E. Harris & Co., Morrisville. *Buckeye Prime.* Guaranteed to contain *38.62* crude protein; guaranty fulfilled (winter sampling).

BUCKEYE COTTON OIL Co., Cincinnati, O. A. H. McLeod Milling Co., St. Johnsbury. *Buckeye.* Guaranteed to contain *38.62* percent crude protein, but failed by one percent to fulfill guaranty (spring sampling).

S. P. DAVIS, Little Rock, Ark. Chas. M. Seaver, Williamstown; J. G. Turnbull & Co., Orleans. *Good Luck.* Guaranteed to contain *41* percent crude protein; guaranty fulfilled (winter sampling).

S. P. DAVIS, Little Rock, Ark. Davis Feed Co., Rutland; A. G. Spaulding, Ludlow; Chas. M. Seaver, Williamstown. *Good Luck.* Guaranteed to contain *41* percent crude protein; guaranty fulfilled (spring sampling).

DIXIE COTTON OIL Co., Montgomery, Ala. W. R. White, North Bennington. *Prime.* Guaranteed to contain *41* percent crude protein; guaranty fulfilled.

EMPIRE COTTON OIL Co., Atlanta Ga. City Feed Co., St. Albans. *Gilt Edge.* Guaranteed to contain *38* percent crude protein; guaranty fulfilled (winter sampling).

EMPIRE COTTON OIL Co., Atlanta, Ga. C. E. Miller, Wells River; City Feed Co., St. Albans; H. I. Randall, Wolcott. *Gilt Edge.* Guaranteed to contain *38* percent crude protein, but failed by a little more than a half percent to fulfill guaranty (spring sampling).

HUMPHREYS, GODWIN Co., Memphis, Tenn. E. W. Bailey & Co., Montpelier; A. N. Washburn, Bethel; Richmond & Son, Northfield; E. I. Benson, Woodstock; A. B. Kilbourne, Bristol; L. L. Marsh, Enosburg Falls; R. S. Clark, Barre; Clark & Davidson, Groton. *Dixie.* Guaranteed to contain *38.62* percent crude protein, but failed by nearly two percent to fulfill guaranty (winter sampling).

HUMPHREYS, GODWIN Co., Memphis, Tenn. E. W. Bailey & Co., Montpelier; Burditt Bros., Rutland; S. P. Curtis & Son, Rutland; E. T. & H. K. Ide, St. Johnsbury; F. M. Sherman, Newport. *Dixie.* Guaranteed to contain *38.62* percent crude protein, but failed by one and one-half percent to fulfill guaranty (spring sampling).

HUMPHREYS, GODWIN Co., Memphis, Tenn. E. T. Seabury Estate, Waterbury; H. K. Foster, South Royalton. *Bull.* Guaranteed to contain *41* percent crude protein, but failed by two and one-half percent to fulfill guaranty (winter sampling).

HUMPHREYS, GODWIN Co., Memphis, Tenn. E. T. Seabury Estate, Waterbury. *Bull.* Guaranteed to contain *41* percent crude protein, but failed by three and one-half percent to fulfill guaranty (spring sampling).

HUMPHREYS, GODWIN Co., Memphis, Tenn. E. E. Harris & Co., Morrisville; Richmond Lumber Co., Richmond. *Forfat.* Guaranteed to contain *38.55* percent crude protein, but failed by one and two-thirds percent to fulfill guaranty (winter sampling).

HUMPHREYS, GODWIN Co., Memphis, Tenn. Burlington Flouring Co., Burlington. *Forfat.* Guaranteed to contain *38.55* percent crude protein, but failed by one and one-half percent to fulfill guaranty (spring sampling).

HUMPHREYS, GODWIN Co., Memphis, Tenn. C. O. Fowler, North Troy. ———. Guaranteed to contain *37.84* percent crude protein; guaranty fulfilled (spring sampling).

LANIER BROS., Nashville, Tenn. A. D. Pease, Burlington. *Canary.* Guaranteed to contain *41* percent crude protein, but failed by one percent to fulfill guaranty (spring sampling).

J. M. MACDONALD, Cincinnati, O. A. H. McLeod Milling Co., St. Johnsbury. *Kineda.* Guaranteed to contain *38.6* percent crude protein; guaranty fulfilled (winter sampling).

J. M. MACDONALD, Cincinnati, O. F. D. Lapelle, Swanton. *Kineda.* Guaranteed to contain *38.6* percent crude protein, but failed by one and one-quarter percent to fulfill guaranty (spring sampling).

C. L. MONTGOMERY & Co., Memphis, Tenn. Griswold & Mackinnon, St. Johnsbury; Mathews & Hall, Orleans. *Canary.* Guaranteed to contain *38.63* percent crude protein; guaranty fulfilled (winter sampling).

C. L. MONTGOMERY & Co., Memphis, Tenn. R. L. Clark & Co., Barre. *Canary Extra.* Guaranteed to contain *41* percent crude protein, but failed by two-thirds of one percent to fulfill guaranty (spring sampling).

C. L. MONTGOMERY & Co., Memphis, Tenn. H. I. Randall, Wolcott. *Canary.* Guaranteed to contain *38.63* percent crude protein, but failed by almost three percent to fulfill guaranty (spring sampling).

J. E. SOPER Co., Boston, Mass. E. G. & A. W. Norton, Vergennes; J. G. Turnbull & Co., Orleans; H. E. Shaw, Stowe; E. T. & H. K. Ide, St. Johnsbury; G. S. Welsh, Groton. *Pioneer.* Guaranteed to contain *41* percent crude protein, but failed by almost two percent to fulfill guaranty (winter sampling).

J. E. SOPER Co., Boston, Mass. E. T. & H. K. Ide, St. Johnsbury; A. D. Pease, Burlington; J. G. Turnbull & Co., Orleans; F. H. Walker Manchester. *Pioneer.* Guaranteed to contain *41* percent crude protein, but failed by more than three percent to fulfill guaranty (spring sampling).

UNION BROKERAGE AND COMMISSION Co., Vicksburg, Miss., and New Orleans, La. A. D. Pease, Burlington. *Durjan.* Guaranteed to contain *41* percent crude protein, but failed by one-third of a percent to fulfill guaranty (spring sampling).

UNION SEED & FERTILIZER Co., Huntsville, Ala. W. R. White, North Bennington. *American Red Tag.* Guaranteed to contain *38.55* percent crude protein; guaranty fulfilled (winter sampling).

UNION SEED & FERTILIZER Co., Clarksdale, Miss. E. T. & H. K. Ide, St. Johnsbury; E. Crosby & Co., Brattleboro. *American Red Tag.* Guaranteed to contain *38.55* percent crude protein; guaranty fulfilled (spring sampling).

LINSEED MEALS

AMERICAN LINSEED Co., New York, N. Y. G. W. Rose, Middlebury. *Hypro Pure ("new" process).* Guaranteed to contain *36* percent crude protein; guaranty fulfilled.

AMERICAN LINSEED Co., New York, N. Y. A. D. Pease, Burlington. *Hypro Pure ("new" process).* Guaranteed to contain *38* percent crude protein; guaranty fulfilled.

AMERICAN LINSEED Co., New York, N. Y. I. Gray, West Danville. ——— (*"new" process*). Guaranteed to contain *36* percent crude protein; guaranty fulfilled.

AMERICAN LINSEED CO., New York, N. Y. H. S. Buttles' Estate, Brandon; R. L. Clark, Barre; Richmond & Son, Northfield; J. E. Foster, Underhill; Madden & Trumbull, White River Junction. *Old Process*. Guaranteed to contain *34* percent crude protein; guaranty fulfilled.

AMERICAN LINSEED CO., New York, N. Y. City Feed Co., St. Albans; St. Albans Feed Co., St. Albans; Clark & Devine, Northfield; E. W. Bailey & Co., Montpelier. *Old Process*. Guaranteed to contain *34* percent crude protein; guaranty fulfilled.

MIDLAND LINSEED PRODUCTS CO., Minneapolis, Minn. A. B. Kilbourne, Bristol; C. E. Miller, Wells River; E. W. Bailey & Co., Montpelier. *Old Process*. Guaranteed to contain *32* percent crude protein; guaranty fulfilled.

MINNESOTA LINSEED OIL CO., Minneapolis, Minn. E. Crosby & Co., Brattleboro. ———. Guaranteed to contain *38* percent crude protein; guaranty fulfilled.

SPENCER, KELLOGG & SON, INC., Buffalo, N. Y. Geo. Shorey, Lyndonville. *Old Process*. Guaranteed to contain *36* percent crude protein; guaranty fulfilled.

SPENCER, KELLOGG & SON, INC., Buffalo, N. Y. Swerdfeger & Davis, Marshfield; J. H. Hewitt, South Royalton; H. Waite & Son, Morrisville. *Old Process*. Guaranteed to contain *33* percent crude protein; guaranty fulfilled.

SPENCER, KELLOGG & SON, INC., Buffalo, N. Y. L. L. Marsh, Enosburg Falls; R. L. Clark, Barre; E. Crosby & Co., Brattleboro. *Old Process*. Guaranteed to contain *33* percent crude protein; guaranty fulfilled.

TOLEDO SEED & OIL CO., Toledo, O. John Burdick, Wallington; A. H. McLeod Milling Co., St. Johnsbury. *Old Process*. Guaranteed to contain *30* percent crude protein; guaranty fulfilled.

TOLEDO SEED & OIL CO., Toledo, O. A. H. McLeod Milling Co., St. Johnsbury; Bradford Mill, Bradford; Burditt Bros., Rutland; Burditt Bros., Ludlow. *Old Process*. Guaranteed to contain *30* percent crude protein; guaranty fulfilled.

GLUTEN FEEDS AND MEAL

AMERICAN MAIZE PRODUCTS CO., New York, N. Y. E. T. & H. K. Ide, St. Johnsbury; MacDiarmid & Co., Newport. *Cream of Corn*. Guaranteed to contain *24* percent crude protein; guaranty fulfilled.

AMERICAN MAIZE PRODUCTS CO., New York, N. Y. L. L. Marsh, Enosburg Falls. *Cream of Corn*. Guaranteed to contain *24* percent crude protein; guaranty fulfilled.

AMERICAN MAIZE PRODUCTS CO., New York, N. Y. A. B. Kilbourne, Bristol. *Cream of Corn*. Guaranteed to contain *23* percent crude protein; guaranty fulfilled.

CLINTON SUGAR REFINING CO., Clinton, Io. Richmond & So., Northfield; F. M. Sherman & Son, Newport; E. W. Bailey & Co., Montpelier. *Clinton*. Guaranteed to contain *23* percent crude protein; guaranty fulfilled.

CLINTON SUGAR REFINING CO., Clinton, Io. Chas. M. Seaver, Williamstown; F. M. Sherman & Son, Newport; Geo. Shorey, Lyndonville. *Clinton*. Guaranteed to contain *23* percent crude protein; guaranty fulfilled.

CORN PRODUCTS REFINING CO., New York, N. Y. E. T. Seabury Estate, Waterbury; Half Century Store Co., Randolph; G. W. Marble, Woodstock. *Diamond Corn Gluten Meal*. Guaranteed to contain *40* percent crude protein; guaranty fulfilled.

CORN PRODUCTS REFINING CO., New York, N. Y. Charlotte Feed Co., Charlotte; J. D. Thompson, Norwich; City Feed Co., St. Albans; H. A. Gray, Cambridge; Kempton Mills, Barre. *Buffalo*. Guaranteed to contain *23* percent crude protein; guaranty fulfilled.

CORN PRODUCTS REFINING CO., New York, N. Y. Burditt Bros., Rutland; Kempter Mills, Barre; E. T. & H. K. Ide, St. Johnsbury; Nelson Bros., Springfield; J. G. Turnbull & Co., Orleans. *Buffalo*. Guaranteed to contain *23* percent crude protein; guaranty fulfilled.

CORN PRODUCTS REFINING CO., New York, N. Y. E. W. Bailey & Co., Montpelier. *Crescent*. Guaranteed to contain *23* percent crude protein; guaranty fulfilled.

CORN PRODUCTS REFINING CO., New York, N. Y. S. Sherman & Son, Poultney. *Globe*. Guaranteed to contain *23* percent crude protein; guaranty fulfilled.

Douglas Co., Cedar Rapids, Ia. Farmers' Exchange, Bradford; H. S. Buttles' Estate, Brandon; H. B. Parkhurst, North Troy; Clark & Devine, Northfield. *Douglas.* Guaranteed to contain *23* percent crude protein; guaranty fulfilled.

Douglas Co., Cedar Rapids, Io. Burditt Bros., Rutland; Guild Grain Store, Ludlow; Richmond Lumber Co., Richmond. *Douglas.* Guaranteed to contain *23* percent crude protein; guaranty fulfilled.

J. C. **Hubinger Bros.** Co., Keokuk, Ia. C. W. Sherman Estate, West Rupert; S. Sherman & Son, Inc., Poultney. *KKK.* Guaranteed to contain *23* percent crude protein; guaranty fulfilled.

A. E. **Staley Manufacturing** Co., Decatur, Ill. Clark & Devine, Northfield. *Staley's.* Guaranteed to contain *23* percent crude protein, but failed by about one-half percent to fulfill guaranty.

DISTILLERS' DRIED GRAINS

Ajax Milling and Feed Co., New York, N. Y. L. L. Marsh, Enosburg Falls; Burditt Bros., Brandon; Wm. Morrison, Barnet. *Ajax Flakes.* Ingredients as stated by manufacturer, "Corn distillers' grains." Guaranteed to contain *30* percent crude protein; guaranty fulfilled.

Ajax Milling and Feed Co., Hammond, Ind. Davis Feed Co., Rutland. Griswold & Mackinnon, St. Johnsbury; Guild Grain Store, Ludlow. *Ajax Flakes.* Ingredients as stated by manufacturer, "Corn distillers' grains." Guaranteed to contain *30* percent crude protein, but failed by more than one and one-half percent to fulfill guaranty.

Clarke Bros. & Co., Peoria, Ill. H. E. Shaw, Stowe; J. D. Thompson, Norwich; E. E. Harris & Co., Morrisville. *Empire State Dairy Feed.* Ingredients as stated by manufacturer, "Corn distillers' dried grains." Guaranteed to contain *28* percent crude protein, but failed by a half percent to fulfill guaranty.

Clarke Bros. & Co., Peoria, Ill. E. W. Bailey & Co., Montpelier; I. Gray, West Danville; L. L. Marsh, Enosburg Falls. *Empire State Dairy Feed.* Ingredients as stated by manufacturer, "Corn distillers' dried grains." Guaranteed to contain *28* percent crude protein; guaranty fulfilled.

Dewey Bros. Co., Blanchester, O. L. L. Marsh, Enosburg Falls; Charlotte Feed Co., Charlotte; Miles, McMahon & Son, Stowe. *Eagle 3D Dewey.* Guaranteed to contain *30* percent crude protein; guaranty fulfilled.

Dewey Bros. Co., Blanchester, O. C. E. Miller, Wells River. *Eagle 3D Dewey.* Guaranteed to contain *30* percent crude protein, but failed by nearly one percent to fulfill guaranty.

Dewey Bros. Co., Blanchester, O. R. Webster & Son, Barton; C. E. Miller, Wells River; E. Crosby & Co., Brattleboro. *Eagle 3D Dewey.* Guaranteed to contain *30* percent crude protein; guaranty fulfilled.

Dewey Bros. Co., Blanchester, O. E. T. Seabury Estate, Waterbury. *Corn 3D.* Guaranteed to contain *26* percent crude protein; guaranty fulfilled.

Dewey Bros. Co., Blanchester, O. F. D. Lapelle & Co., Swanton. *Corn 3D.* Guaranteed to contain *26* percent crude protein; guaranty fulfilled.

Grain Products Sales Co., Buffalo, N. Y. L. A. Sheldon, Rupert. *Columbia.* Guaranteed to contain *30* percent crude protein; guaranty fulfilled.

Hottelet Co., Milwaukee, Wis. E. T. & H. K. Ide, St. Johnsbury; Half Century Store Co., Randolph; H. A. Slayton & Co., Morrisville; Chas. M. Seaver, Williamstown; G. S. Welsh, Groton. *Hector.* Guaranteed to contain *30* percent crude protein; guaranty fulfilled.

Hottelet Co., Milwaukee, Wis. Walker & Brock, Barnet; Bradford Mills, Bradford; E. Crosby & Co., Brattleboro; St. Albans Feed Co., St. Albans. *Hector.* Guaranteed to contain *30* percent crude protein; guaranty fulfilled.

Ubiko Milling Co., Cincinnati, O. H. K. Foster, South Royalton; Sweat-Comings Co., Richford. *Fourex.* Guaranteed to contain *31* percent crude protein, but failed by nearly a half percent to fulfill guaranty.

Ubiko Milling Co., Cincinnati, O. E. L. Kibby, Williamstown; St. Albans Grain Co., St. Albans. *Fourex.* Guaranteed to contain *30* percent crude protein, but failed by two and three-quarters percent to fulfill guaranty.

BREWERS' DRIED GRAINS

Anheuser-Busch Brewing Association, St. Louis, Mo. E. G. & A. W. Norton, Vergennes. ———. Guaranteed to contain *22* percent crude protein; guaranty fulfilled.

Anheuser-Busch Brewing Association, St. Louis, Mo. Guild Grain Store, Ludlow. ———. Guaranteed to contain *22* percent crude protein; guaranty fulfilled.

Atlantic Export Co., Chicago, Ill. Perley & Leavens, Cambridge. ———. Guaranteed to contain *25* percent crude protein, but failed by three and three-quarters percent to fulfill guaranties.

Farmers' Feed Co., Buffalo, N. Y. E. I. Benson, Woodstock; City Feed Co., St. Albans; A. B. Kilbourne, Bristol; E. H. Edson, Randolph; Richmond Lumber Co., Richmond. *Bull.* Guaranteed to contain *27.2* percent crude protein; guaranty fulfilled.

Farmers' Feed Co., Buffalo, N. Y. L. L. Marsh, Enosburg Falls; E. W. Bailey & Co., Montpelier; S. P. Curtis & Son, Rutland; Griswold & Mackinnon, St. Johnsbury; R. Webster, Barton. *Bull.* Guaranteed to contain *27.2* percent crude protein; guaranty fulfilled.

Fleischmann Co., Chicago, Ill. John Burdick, Wallingford. *Fleischmann's.* Guaranteed to contain *19* percent crude protein, but failed by more than one and one-half percent to fulfill guaranty.

WHEAT OFFALS

Wheat Brans

Bill, Bell & Co., Ogdensburg, N. Y. H. S. Buttles' Estate, Brandon. *Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *14.25* percent crude protein; guaranty fulfilled.

Blake Milling Co., Edwardsville, Ill. F. D. Lapelle & Co., Swanton. *Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *15.5* percent crude protein; guaranty fulfilled.

Bowersock Mills & Power Co., Lawrence, Kan. J. G. Turnbull & Co., Orleans. *Pure Bran* with screenings. Guaranteed to contain *14.5* percent crude protein; guaranty fulfilled.

Burlington Flouring Co., Burlington, Vt. Burlington Flouring Co., Burlington, Vt. *Perfection Cereal Bran.* (Unguarantied). Contained 12.1 percent crude protein.

Geo. C. Christian, Minneapolis, Minn. Geo. J. Stannard, Fair Haven; E. T. & H. K. Ide, St. Johnsbury. *Jersey Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

Claro Milling Co., Lakeville, Minn. City Feed Co., St. Albans. *Claro Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

Wm. A. Coombes Milling Co., Coldwater, Mich. *Bran* with screenings. E. T. & H. K. Ide, Bradford. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

Eagle Roller Mill Co., New Ulm, Minn. Griswold & Mackinnon, St. Johnsbury. *Bran.* Guaranteed to contain *15.45* percent crude protein; failed by a half percent to fulfill guaranty.

B. A. Eckhardt Milling Co., Chicago, Ill. E. Lane & Son, Newport. *Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

Federal Milling Co., Lockport, N. Y. A. N. Washburn, Bethel. *Dairy Maid Bran.* Guaranteed to contain *14.5* percent crude protein; guaranty fulfilled.

Federal Milling Co., Lockport, N. Y. C. E. Miller, Wells River. *Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

Federal Milling Co., Lockport, N. Y. E. Lane & Son, Newport. *Lucky Spring Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *12* percent crude protein; guaranty fulfilled.

GWINN MILLING Co., Columbus, O. Griswold & Mackinnon, St. Johnsbury. *Gwinn's Bran.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

HECKER-JONES-JEWELL MILLING Co., Buffalo, N. Y. E. I. Benson, Woodstock. *Choice Bran* with trace of screenings. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

HUNTER-ROBINSON-WENZ MILLING Co., St. Louis, Mo. C. McFarland & Son, Barton; Griswold & Mackinnon, St. Johnsbury. *Dreadnought Xtra Coarse Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *15.5* percent crude protein; guaranty fulfilled.

HUNTER-ROBINSON-WENZ MILLING Co., St. Louis, Mo. Geo. J. Stannard, Fair Haven; C. W. Hartwell, Newbury. *Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *15.5* percent crude protein; guaranty fulfilled.

KEHLER FLOUR MILLS Co., St. Louis, Mo. John Burdick, Wallingford. *Palace Bran.* Guaranteed to contain *14.5* percent crude protein; guaranty fulfilled.

KEMPER MILL & ELEVATOR Co., Kansas City, Mo. C. W. Sherman's Estate, West Rupert; H. M. Brown, Castleton; E. H. Mason, Randolph; E. Lane & Son, Newport; E. W. Bailey & Co., Montpelier; Swerdfeger & Davis, Marshfield; J. D. Thompson, Norwich. *Anchor Bran* with ground screenings. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

LEE WARREN MILLING Co., Salina, Kans. Burlington Flouring Co., Burlington. *Bran* and screenings. Guaranteed to contain *14.5* percent crude protein; guaranty fulfilled.

LIBERTY MILLS, Nashville, Tenn. Strong & Goddard, Hyde Park. *Pure Bran* with screenings. Guaranteed to contain *14.5* percent crude protein; guaranty fulfilled.

LISTMAN MILLING Co., ————. Charlotte Feed Co., Charlotte. *Elmco Bran.* Guaranteed to contain *15.51* percent crude protein; guaranty fulfilled.

MANEY MILLING Co., Omaha, Neb. L. S. Robie, Hardwick. *Bran* with screenings. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

MANSFIELD MILLING Co., ————. Burditt Bros., Rutland. *Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

MAPLE LEAF MILLING Co., LTD., Toronto, Can. H. B. Parkhurst, North Troy. *Bran.* Guaranteed to contain *15.5* percent crude protein; guaranty fulfilled.

NATIONAL MILLING Co., Toledo, O. MacDiarmid & Co., Newport. *Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *16.5* percent crude protein; contained almost 3 percent less than guaranty, a shortage of one-sixth the total amount.

NATIONAL FEED Co., St. Louis, Mo. L. L. Marsh, Enosburg Falls. *Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *14.5* percent crude protein; guaranty fulfilled.

NIAGARA FALLS MILLING Co., Niagara Falls, N. Y. E. H. Mason, Randolph; E. T. & H. K. Ide, Bradford. *Choice Bran.* Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

NORTHWESTERN CONSOLIDATED MILLING Co., Minneapolis, Minn. Mathews & Hall, Orleans; Half Century Store Co., Randolph; H. K. Foster, South Royalton; Griswold & Mackinnon, St. Johnsbury. *Pure Bran.* Guaranteed to contain *14.5* percent crude protein; guaranty fulfilled.

OGILVIE FLOUR MILLS Co., Fort William, Ont. Geo. Shorey, Lyndonville. *Fancy Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *15* percent crude protein, but failed by three-quarters of a percent to fulfill guaranty.

OGILVIE FLOUR MILLS Co., Fort William, Ont. Star Feed Store, Burlington. *Fancy Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

PELICAN RIVER MILLING Co., Elizabeth, Minn. E. T. & H. K. Ide, St. Johnsbury. ————. Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

PILLSBURY MILLING Co., Minneapolis, Minn. E. T. & H. K. Ide, St. Johnsbury. *Pillsbury's Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

PILLSBURY MILLING Co., Minneapolis, Minn. E. Lane & Son, Newport; A. B. Kilbourne, Bristol; H. E. Shaw, Stowe. *Pillsbury's Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *14.5* percent crude protein; guaranty fulfilled.

PILLSBURY MILLING Co., Minneapolis, Minn. J. G. Turnbull Co., Orleans. *Pillsbury's Duram Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *11* percent crude protein; guaranty fulfilled.

GEO. P. PLANT MILLING Co., St. Louis, Mo. Chas. M. Seaver, Williamstown. *Bran* with screenings. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

QUAKER OATS Co., Chicago, Ill. G. W. Marble, Woodstock. *Bell Cow Bran.* Guaranteed to contain *14.5* percent crude protein; guaranty fulfilled.

RED WING MILLING Co., Red Wing, Minn. City Feed Co., St. Albans. *Bixota Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *14.1* percent crude protein; guaranty fulfilled.

RED WING MILLING Co., Red Wing, Minn. A. D. Pease, Burlington. *Bixota Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *14.1* percent crude protein; guaranty fulfilled.

ROYAL MILLING Co., Great Falls, Mont. E. T. & H. K. Ide, St. Johnsbury. *Royal Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *15.5* percent crude protein; guaranty fulfilled.

RUSSELL-MILLER MILLING Co., Minneapolis, Minn. E. T. Seabury Estate, Waterbury. *Bran.* Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

SOUTHWESTERN MILLING Co., Kansas City, Mo. Madden & Trumbull, White River Junction; E. H. Mason, Randolph. *Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

F. W. STOCK & SONS, Hillsdale, Mich. G. W. Rose, Middlebury. *Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

DAVID STOTT FLOUR MILLS, Detroit, Mich. R. P. Webster, Barton; C. E. Miller, Wells River. *Winter Bran* with wheat screenings. Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

DAVID STOTT FLOUR MILLS, Detroit, Mich. C. E. Miller, Wells River; Kempton Mills, Barre. *Spring Bran* with wheat screenings. Guaranteed to contain *16* percent crude protein, but failed by almost one percent to fulfill guaranty.

TENNENT & HOYT Co., Lake City, Minn. E. W. Bailey & Co., Swanton. *Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

THOMPSON MILLING Co., Lockport, N. Y. C. W. Sherman Estate, West Rupert. *Winter Bran.* Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

VOIGHT MILLING Co., Grand Rapids, Mich. MacDiarmid & Co., Newport. *Voight's Bran* with mill-run of screenings. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

VOIGHT MILLING Co., Grand Rapids, Mich. E. T. & H. K. Ide, Fairlee; H. E. Shaw, Stowe. *Voight's Bran* with mill-run of screenings. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

WASHBURN MILLS, Minneapolis, Minn. L. L. Marsh, Enosburg Falls; A. B. Kilbourne, Bristol; E. R. Sheldon, Rupert. *Washburn-Crosby's Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *14.5* percent crude protein; guaranty fulfilled.

WESTERN CANADA FLOUR MILLING Co., LTD., ————. E. T. & H. K. Ide, Fairlee; Richmond & Son, Northfield; Sweat-Comings Co., Richford. *Spring Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *14.5* percent crude protein; guaranty fulfilled.

WESTERN FLOUR MILL Co., Davenport, Ia. Geo. J. Stannard, Fair Haven. *Blackhawk Bran* and ground screenings not exceeding the mill-run. Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

YERXA, ANDREWS, THURSTON, Minneapolis, Minn. City Feed Co., St. Albans. *Nokomo's Duram* and ground screenings not exceeding the mill-run. Guaranteed to contain *12* percent crude protein; guaranty fulfilled.

WHEAT MIDDLINGS

AMENDT MILLING CO., Monroe, Mich. H. B. Parkhurst, North Troy. *Pure Amco Middlings.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

ANSTEAD & BURKE, Springfield, O. H. N. Gray, Cambridge. *Middlings* and ground screenings not exceeding the mill-run. Guaranteed to contain *14.5* percent crude protein; guaranty fulfilled.

ATLAS FLOUR MILLS, Milwaukee, Wis. H. W. Myers & Son, Bennington. *Atlas Wheat Middlings* and ground screenings not exceeding the mill-run. (Unguarantied); contained *16.3* percent crude protein.

BARBER MILLING CO., Minneapolis, Minn. J. H. Hewitt, South Royalton. *Fancy White Middlings.* Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

BARBER MILLING CO., Minneapolis, Minn. J. H. Hewitt, South Royalton. *Middlings.* Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

BAY STATE MILLING CO., Winona Minn. E. M. Bixby & Son, Poultney. *Winona Middlings.* Guaranteed to contain *18* percent crude protein, but failed by a little more than two percent to fulfill guaranty.

BILL, BELL & CO., Ogdensburg, N. Y. A. N. Washburn, Bethel. *Flour Middlings.* Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

BILL, BELL & CO., Ogdensburg, N. Y. A. B. Kilbourne, Bristol. *Shorts.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

CANNON VALLEY MILLING CO., ————. Geo. J. Stannard, Fair Haven. *Cannon Valley Middlings.* Guaranteed to contain *18.23* percent crude protein, but failed by nearly one percent to fulfill guaranty.

CATARACT CITY MILLING CO., Niagara Falls, N. Y. Geo. J. Stannard, Fair Haven. *Cataract City Middlings* and ground screenings not exceeding the mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

G. L. CHRISTIAN, Minneapolis, Minn. Madden & Trumbull, White River Junction. *Poland Standard Middlings* and ground screenings not exceeding the mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

L. CHRISTIAN & CO., Minneapolis, Minn. A. N. Washburn, Bethel. *Matchless Standard Middlings.* Guaranteed to contain *15.5* percent crude protein; guaranty fulfilled.

CHAS. M. COX CO., Boston, Mass. W. V. Phelps, Enosburg Falls. *Wirthmore Middlings.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

DETROIT MILLING CO., Detroit, Mich. J. E. Hunt & Son, Jeffersonville. *Fancy Apex Middlings.* Guaranteed to contain *17* percent crude protein, but failed by one and one-quarter percent to fulfill guaranty.

DETROIT MILLING CO., Detroit, Mich. J. E. Hunt & Son, Jeffersonville. *Tiger Pure Middlings.* Guaranteed to contain *17* percent crude protein, but failed by a half percent to fulfill guaranty.

FEDERAL MILLING CO., Lockport, N. Y. T. C. Jennison, Sheldon; J. W. Gillis, Danville. *Lucky Spring Wheat Flour Middlings* and ground screenings not exceeding the mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

FEDERAL MILLING CO., Lockport, N. Y. A. N. Washburn, Bethel; Mathews & Hall, Orleans; D. H. McHugh, Middlebury; Geo. Shorey, Lyndonville. *Dairy Maid Winter Wheat Middlings* and ground screenings not exceeding the mill-run. Guaranteed to contain *13.5* percent crude protein; guaranty fulfilled.

FEDERAL MILLING CO., Lockport, N. Y. A. D. Pease, Burlington. *Dairy Maid Middlings* and ground screenings not exceeding the mill-run. Guaranteed to contain *13.5* percent crude protein; guaranty fulfilled.

GARDNER MILLS, ————. H. S. Buttles' Estate, Brandon. *Snowball White Middlings* and ground screenings not exceeding the mill-run. (Unguarantied); contained *17.1* percent crude protein.

GWINN MILLING Co., Columbus, O. Griswold & Mackinnon, St. Johnsbury. *Middlings*, with cleansed, ground wheat screenings not exceeding mill-run. Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

HECKER-JONES-JEWELL MILLING Co., Buffalo, N. Y. Charlotte Feed Co., Charlotte. *Standard Middlings*, with mill-run screenings. Guaranteed to contain *16.5* percent crude protein; guaranty fulfilled.

LA GRANGE MILLS, Red Wing, Minn. Griswold & Mackinnon, St. Johnsbury. *La Grange Fine Middlings*. Guaranteed to contain *15.5* percent crude protein; guaranty fulfilled.

LISTMAN MILLING Co., ————. Charlotte Feed Co., Charlotte. *Elmco Fancy White Middlings*. Guaranteed to contain *16.09* percent crude protein, but failed by nearly a half percent to fulfill guaranty.

NATIONAL MILLING Co., Toledo, O. Perley & Leavens, Cambridge; Clark & Davidson, Groton. *Middlings*. Guaranteed to contain *17.5* percent crude protein, but failed by one-quarter percent to fulfill guaranty.

NIAGARA FALLS MILLING Co., Niagara Falls, N. Y. City Feed Co., St. Albans; F. P. Edgerton, Wallingford. *Choice Middlings*. Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

NORTHWESTERN CONSOLIDATED MILLING Co., Minneapolis, Minn. Half Century Store Co., Randolph. *XXX Comet Middlings* and ground screenings not exceeding the mill-run. Guaranteed to contain *16.5* percent crude protein; guaranty fulfilled.

NORTHWESTERN CONSOLIDATED MILLING Co., Minneapolis, Minn. Mathews & Hall, Orleans; A. B. Kilbourne, Bristol. *Middlings* and ground screenings not exceeding the mill-run. Guaranteed to contain *15.5* percent crude protein; guaranty fulfilled.

NORTHWESTERN CONSOLIDATED MILLING Co., Minneapolis, Minn. E. W. Bailey & Co., Swanton; F. M. Sherman & Co., Newport; F. A. Sheldon, Rupert. *Standard Middlings* and ground screenings not exceeding the mill-run. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

OGILVIE FLOUR MILLS Co., Winnipeg, Man. E. T. & H. K. Ide, Fairlee; Richmond Lumber Co., Richmond. *O Middlings*. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

PILLSBURY MILLING Co., Minneapolis, Minn. Chas. M. Seaver, Williamstown; A. B. Kilbourne, Bristol. *Pillsbury's XX Middlings*. Guaranteed to contain *17* percent crude protein; guaranty fulfilled.

RUSSELL-MILLER MILLING Co., Minneapolis, Minn. L. L. Marsh, Enosburg Falls. *Flour Middlings*. Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

RUSSELL-MILLER MILLING Co., Minneapolis, Minn. H. S. Buttles' Estate, Brandon; Clark & Devine, Northfield; Miles, McMahon & Son, Stowe; J. D. Thompson, Norwich. *Standard Middlings*. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

DAVID STOTT FLOUR MILLS, Detroit, Mich. C. C. Miller, Wells River. *Stott's Middlings*. Guaranteed to contain *17* percent crude protein; guaranty fulfilled.

DAVID STOTT FLOUR MILLS, Detroit, Mich. Charlotte Feed Co., Charlotte; H. C. Skeels & Co., Swanton. *Stott's Pennant Pure Middlings*. Guaranteed to contain *17* percent crude protein; guaranty fulfilled.

THOMPSON MILLING Co., Lockport, N. Y. C. W. Sherman Estate, W. Rupert. *Winter White Middlings* and ground screenings not exceeding the mill-run. Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

THOMPSON MILLING Co., Lockport, N. Y. Geo. J. Stannard, Fair Haven; S. Sherman & Son, Inc., Poultney. *Angelus Flour Middlings* and ground screenings not exceeding the mill-run. Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

TIOGA MILL & ELEVATOR Co., Waverly, N. Y. F. A. Sheldon, Rupert. *Waverly Flour Middlings* and ground screenings not exceeding the mill-run. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

VALLEY CITY MILLING Co., Grand Rapids, Mich. Madden & Trumbull, White River Junction. *Farmers' Favorite Standard Middlings* and ground screenings not exceeding the mill-run. Guaranteed to contain *15.22* percent crude protein; guaranty fulfilled.

VALLEY CITY MILLING Co., Grand Rapids, Mich. Gregory Grain Co., Burlington. *Farmers' Favorite Middlings* and ground screenings not exceeding the mill-run. Guaranteed to contain *15.22* percent crude protein; guaranty fulfilled.

VERMONT CEREAL Co., Burlington, Vt. H. B. Parkhurst, North Troy. *Waumbeck Dairy Middlings* and ground screenings not exceeding the mill-run. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

VERMONT CEREAL Co., Burlington, Vt. A. D. Pease, Burlington, *Waumbeck Dairy Middlings* and ground screenings not exceeding the mill-run. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

VOIGHT MILLING Co., Grand Rapids, Mich. A. B. Kilbourne, Bristol. *Crescent Middlings.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

WASHBURN MILLS, Minneapolis, Minn. E. W. Bailey & Co., Montpelier; E. R. Sheldon, Rupert. *Washburn-Crosby's Wheat Middlings* and ground screenings not exceeding the mill-run. Guaranteed to contain *17* percent crude protein, but failed by more than a half percent to fulfill guaranty.

WASHBURN MILLS, Minneapolis, Minn. Sweat-Comings Co., Richford; E. I. Benson, Woodstock. *Washburn-Crosby's Standard Middlings* and ground screenings not exceeding the mill-run. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

WHEAT MIXED FEEDS

ACME-EVANS Co., Indianapolis, Ind. Burditt Bros., Brandon. *Acme Mixed Feed* and ground screenings not exceeding the mill-run. Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

AMENDT MILLING Co., Monroe, Mich. H. B. Parkhurst, North Troy. *Pure Amco Mixed Feed.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

AMENDT MILLING Co., Monroe, Mich. Farmers' Exchange, Bradford. *Amco Mixed Feed.* Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

E. W. BAILEY & Co., Montpelier, Vt. L. B. Jenne, Derby Center. *Bailey's Mixed Feed.* Guaranteed to contain *16* percent crude protein, but failed by almost one percent to fulfill guaranty.

E. W. BAILEY & Co., Montpelier, Vt. Perley & Leavens, Cambridge; Chas. M. Seaver, Williamstown. *Bailey's Fancy Mixed Feed.* Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

BARBER MILLING Co., Minneapolis, Minn. W. F. Cunningham, St. Albans. *White Satin Mixed Feed.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

WM. A. COOMBES MILLING Co., Coldwater, Mich. E. E. Harris & Co., Morrisville. *Mixed Feed* and ground screenings not exceeding the mill-run. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

CHAS. M. COX Co., Boston, Mass. W. V. Phelps, Enosburg Falls; H. K. Foster, South Royalton. *Wirthmore Mixed Feed.* Guaranteed to contain *16* percent crude protein, but failed by one percent to fulfill guaranty.

FEDERAL MILLING Co., Lockport, N. Y. J. E. Foster, Underhill. *Lucky Spring Mixed Feed* and ground screenings not exceeding the mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

FEDERAL MILLING Co., Lockport, N. Y. C. O. Fuller, North Troy; R. L. Clark, Barre. *Dairy Maid Winter Wheat Mixed Feed* and ground screenings not exceeding the mill-run. Guaranteed to contain *13.5* percent crude protein; guaranty fulfilled.

GRISWOLD & MACKINNON, St. Johnsbury, Vt. Griswold & Mackinnon, St. Johnsbury; MacDiarmid & Co., Newport. *Xtra Good Mixed Feed.* Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

GRISWOLD & MACKINNON, St. Johnsbury, Vt. J. E. Turnbull & Co., Orleans. *Creamery Mixed Feed.* Guaranteed to contain *15* percent crude protein, but failed by one percent to fulfill guaranty.

HECKER-JONES-JEWELL MILLING CO., Buffalo, N. Y. E. Lane & Sons, Newport; E. I. Benson, Woodstock. *Hecker's Mixed Feed* with mill-run screenings. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

KEHLOR FLOUR MILL CO., St. Louis, Mo. E. I. Benson, Woodstock. *Kehlor's Mill Mixed Feed* and ground screenings not exceeding the mill-run. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

KEMPER MILL & ELEVATOR CO., Kansas City, Mo. A. H. McLeod Milling Co., St. Johnsbury; R. P. Webster, Barton; E. T. Seabury Estate, Waterbury. *Crescent Mixed Feed* and ground wheat screenings. Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

LAWRENCEBURG ROLLER MILLS CO., Lawrenceburg, Ind. H. A. Slayton & Co., Morrisville; D. H. McHugh, Middlebury. *Snowflake Mixed Feed* and ground screenings not exceeding the mill-run. Guaranteed to contain *15.2* percent crude protein; guaranty fulfilled.

A. H. MCLEOD MILLING CO., St. Johnsbury, Vt. C. W. Hartwell, Newbury; R. P. Webster, Barton. *Brooks' Fancy Mixed Feed.* Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

A. H. MCLEOD MILLING CO., St. Johnsbury, Vt. H. B. Sturtevant, East Fairfield. *Sturtevant's Mixed Feed.* (Unguarantied); contained *14.7* percent crude protein.

NATIONAL MILLING CO., Toledo, O. E. W. Bailey & Co., Montpelier. *Osota Mixed Feed.* Guaranteed to contain *17* percent crude protein, but failed by almost two and one-half percent to fulfill guaranty.

NATIONAL MILLING CO., Toledo, O. A. B. Kilbourne, Bristol; J. D. Thompson, Norwich; H. K. Foster, South Royalton; E. W. Bailey & Co., Montpelier. *Osota Mixed Feed.* Guaranteed to contain *17* percent crude protein, but failed by one and one-half percent to fulfill guaranty.

NATIONAL MILLING CO., Toledo, O. H. P. Munson Estate, Morrisville; J. D. Thompson, Norwich; Clark & Davidson, Groton. *Pennant Mixed Feed.* Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

NATIONAL MILLING CO., Toledo, O. Chas. M. Seaver, Williamstown. *Pennant Quality Mixed Feed.* Guaranteed to contain *16* percent crude protein, but failed by one percent to fulfill guaranty.

NIAGARA FALLS MILLING CO., Niagara Falls, N. Y. Chas. M. Seaver, Williamstown. *Perfect Mixed Feed.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

NORTHWESTERN CONSOLIDATED MILLING CO., Minneapolis, Minn. Davis Feed Co., Rutland. *Planet Mixed Feed* and ground screenings not exceeding the mill-run. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

NORTHWESTERN CONSOLIDATED MILLING CO., Minneapolis, Minn. F. M. Sherman, Newport. *Planet Mixed Feed* and ground screenings not exceeding the mill-run. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

NORTHWESTERN CONSOLIDATED MILLING CO., Minneapolis, Minn. F. P. Edgerton, Wallingford. *Planet Mixed Feed* and ground screenings not exceeding the mill-run. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

NORTHWESTERN CONSOLIDATED MILLING CO., Minneapolis, Minn. R. P. Webster & Son, Barton; Half Century Store Co., Randolph; Joyce & Marshall, West Burke. *Planet Mixed Feed* and ground screenings not exceeding the mill-run. Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

OGDENSBURG ROLLER MILLS, Ogdensburg, N. Y. C. O. Fowler, North Troy. *Winter Mixed Feed.* (Unguarantied); contained *14.5* percent crude protein.

PILLSBURY'S MILLS, Minneapolis, Minn. E. T. & H. K. Ide, St. Johnsbury; A. B. Kilbourne, Bristol; E. T. Seabury Estate, Waterbury; H. E. Shaw, Stowe. *Fancy Mixed Feed* and ground screenings not exceeding the mill-run. Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

PILLSBURY Co., Minneapolis, Minn. L. L. Marsh, Enosburg Falls. *Pillsbury's Fancy Mixed Feed* and ground screenings not exceeding the mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

PORTLAND MILLING Co., Portland, Mich. E. T. & H. K. Ide, St. Johnsbury; F. M. Sherman, Newport; A. N. Washburn, Bethel. *Champion Mixed Feed* and ground screenings not exceeding the mill-run. Guaranteed to contain *13.56* percent crude protein; guaranty fulfilled.

RUSSELL-MILLER MILLING Co., Minneapolis, Minn. Miles, McMahon & Son, Stowe; L. L. Marsh, Enosburg Falls; E. W. Bailey & Co., Montpelier; L. G. Roundy, West Burke. *Occident Mixed Feed.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

SHEFFIELD-KING MILLING Co., Minneapolis, Minn. E. T. & H. K. Ide, St. Johnsbury. *Gold Mine Mixed Feed and Screenings.* Guaranteed to contain *15.9* percent crude protein; guaranty fulfilled.

SPARKS MILLING Co., Alton, Ill. E. T. & H. K. Ide, St. Johnsbury. *Try Me Winter* and ground screenings not exceeding the mill-run. Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

SPARKS MILLING Co., Alton, Ill. Richmond Lumber Co., Richmond. *Wabash Mixed Feed* and ground screenings not exceeding the mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

F. W. STOCK & SONS, Hillsdale, Mich. H. S. Buttles' Estate, Brandon. *Monarch Fancy Mixed Feed* with mill-run screenings. Guaranteed to contain *16* percent crude protein, but failed by three-quarters of a percent to fulfill guaranty.

F. W. STOCK & SONS, Hillsdale, Mich. Strong & Goddard, Hyde Park; D. H. McHugh, Middlebury. *Superior Mixed Feed* with mill-run screenings. Guaranteed to contain *16* percent crude protein, but failed by one percent to fulfill guaranty.

DAVID STOTT FLOUR MILLS, Detroit, Mich. H. B. PARKHURST, North Troy. *Stott's Honest Mixed Feed.* Guaranteed to contain *16.5* percent crude protein, but failed by one percent to fulfill guaranty.

DAVID STOTT FLOUR MILLS, Detroit, Mich. H. B. Parkhurst, North Troy; H. S. Buttles' Estate, Brandon. *Stott's Heavy Pure Mixed Feed.* Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

STRATTON & Co., Concord, N. H. A. H. Merrill Estate, Norwich. *Stratton's Mixed Feed* and ground screenings not exceeding the mill-run. Guaranteed to contain *15.87* percent crude protein; guaranty fulfilled.

ST. ALBANS GRAIN Co., St. Albans, Vt. City Feed Store, St. Albans. A. N. Washburn, Bethel. *Hygrade Mixed Feed* and screenings. Guaranteed to contain *16* percent crude protein, but failed by one and one-half percent to fulfill guaranty.

THOMPSON MILLING Co., Lockport, N. Y. W. F. Cunningham, St. Albans; S. Sherman & Son, Inc., Poultney. *Angelus Mixed Feed* and ground screenings not exceeding the mill-run. Guaranteed to contain *13* percent crude protein; guaranty fulfilled.

VALLEY CITY MILLING Co., Grand Rapids, Mich. Gregory Grain Co., Burlington. *Farmers' Favorite Cow Feed* and ground screenings not exceeding the mill-run. Guaranteed to contain *16.8* percent crude protein, but failed by nearly two percent to fulfill guaranty.

VALLEY CITY MILLING Co., Grand Rapids, Mich. Miles, McMahon & Son, Stowe; E. E. Harris & Co., Morrisville; G. W. Marble, Woodstock. *Farmers' Favorite Cow Feed* and ground screenings not exceeding the mill-run. Guaranteed to contain *16.8* percent crude protein, but failed by one percent to fulfill guaranty.

VERMONT CEREAL Co., Burlington, Vt. H. B. Parkhurst, North Troy. J. W. Gillis, Danville. *Waumbeck Special Mixed Feed* and ground screenings not exceeding the mill-run. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

WAGGONER-GATES MILLING Co., Independence, Mo. G. W. Rose, Middlebury. *Mill-run Bran Mixed Feed.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

WASHBURN MILLS, Minneapolis, Minn. E. T. Seabury Estate, Waterbury. *Mixed Feed* and ground screenings not exceeding the mill-run. Guaranteed to contain *12* percent crude protein; guaranty fulfilled.

WILLIAMS BROS., Kent, O. J. D. Thompson, Norwich. *Kent Mixed Feed.* Guaranteed to contain *12* percent crude protein; guaranty fulfilled.

RED DOG FLOUR

ATLAS FLOUR MILLS, Milwaukee, Wis. H. W. Myers & Son, Bennington. *Atlas.* Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

BARBER MILLING CO., Minneapolis, Minn. J. H. Hewitt, South Royalton. *Fancy.* Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

BAY STATE MILLING CO., Winona, Minn. E. M. Bixby & Son, Poultney. *G.* Guaranteed to contain *18* percent crude protein, but failed by a little more than two percent to fulfill guaranty.

EAGLE ROLLER MILL CO., New Ulm, Minn. G. W. Rose, Middlebury. *Superb.* Guaranteed to contain *17* percent crude protein; guaranty fulfilled.

NATIONAL MILLING CO., Minneapolis, Minn. G. W. Rose, Middlebury. *Bob Fancy.* Guaranteed to contain *16* percent crude protein, but failed by one percent to fulfill guaranty.

NIAGARA FALLS MILLING CO., Niagara Falls, N. Y. City Feed Co., St. Albans. *Choice.* Guaranteed to contain *16* percent crude protein, but failed by one and one-half percent to fulfill guaranty.

NORTHWESTERN CONSOLIDATED MILLING CO., Minneapolis, Minn. A. H. McLeod Milling Co., St. Johnsbury; F. A. Sheldon, Rupert; F. M. Sherman & Co., Newport. *XXX Comet.* Guaranteed to contain *16.5* percent crude protein; guaranty fulfilled.

OGDENSBURG ROLLER MILLS, Ogdensburg, N. Y. W. C. Marsh, Sheldon. ————. (Unguarantied); contained *14* percent crude protein.

PILLSBURY CO., Minneapolis, Minn. J. D. Thompson, Norwich; L. L. Marsh, Enosburg Falls. *XXX Daisy.* Guaranteed to contain *17* percent crude protein, but failed by a third of a percent to fulfill guaranty.

RUSSELL-MILLER MILLING CO., Minneapolis, Minn. H. S. Buttles' Estate, Brandon. ————. Guaranteed to contain *16* percent crude protein, but failed by nearly one-half percent to fulfill guaranty.

DAVID STOTT FLOUR MILLS, Detroit, Mich. H. S. Buttles' Estate, Brandon. *Stag.* Guaranteed to contain *15* percent crude protein, but failed by two-thirds of a percent to fulfill guaranty.

WASHBURN-CROSBY CO., Minneapolis, Minn. C. W. Hartwell, Newbury. *Arlington.* (Unguarantied); contained *14.4* percent crude protein.

WASHBURN-CROSBY CO., Minneapolis, Minn. Walker & Brock, Barnet. *Goliath* (*Hecker*). (Unguarantied); contained *13.1* percent crude protein.

WASHBURN MILLS, Minneapolis, Minn. H. E. Shaw, Stowe; E. R. Sheldon, Rupert; Half Century Store Co., Randolph; E. T. & H. K. Ide, St. Johnsbury; Vermont Marble Co., Proctor. *Adrain.* Guaranteed to contain *17* percent crude protein; guaranty fulfilled.

HOMINY FEEDS

AMERICAN HOMINY CO., Indianapolis, Ind. W. F. Cunningham, St. Albans; Chas. M. Seaver, Williamstown. *Homco.* Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

AMERICAN HOMINY CO., Indianapolis, Ind. Cunningham Feed Co., St. Albans; E. Crosby & Co., Brattleboro. *Homco.* Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

BUFFALO CEREAL CO., Buffalo, N. Y. S. P. Carter & Son, Rutland. *Bufceco.* Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

CHAS. M. COX CO., Boston, Mass. City Feed Store, St. Albans. *Wirthmore.* Guaranteed to contain *9.5* percent crude protein; guaranty fulfilled.

CHAS. M. COX CO., Boston, Mass. City Feed Store, St. Albans. *Wirthmore.* Guaranteed to contain *9.5* percent crude protein; guaranty fulfilled.

EAGLE ROLLER MILLING CO., New Ulm, Minn. Burditt Bros., Rutland. ————. Guaranteed to contain *10.37* percent crude protein, but failed by a quarter percent to fulfill guaranty.

EVANS MILLING Co., Indianapolis, Ind. A. D. Pease, Burlington. *Emco Evans.* Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

PATENT CEREALS Co., Geneva, N. Y. E. M. Bixby & Son, Poultney. Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

PLYMOUTH MILLING Co., ————. Burditt Bros., Brandon. *Plymouth's Pure.* Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

QUAKER OATS Co., Chicago, Ill. J. G. Turnbull & Co., Orleans. Griswold & Mackinnon, St. Johnsbury. *Yellow.* Guaranteed to contain *9* percent crude protein; guaranty fulfilled.

QUAKER OATS Co., Chicago, Ill. Burlington Flouring Co., Burlington; A. D. Pease, Burlington. *Yellow.* Guaranteed to contain *9* percent crude protein; guaranty fulfilled.

M. G. RANKIN & Co., Milwaukee, Wis. E. W. Bailey & Co., Montpelier. *Jersey.* Guaranteed to contain *10* percent crude protein, but failed by a half percent to fulfill guaranty.

DRIED BEET PULPS

AMERICAN SUGAR Co., Saginaw, Mich. E. W. Bailey & Co., Montpelier. ————. (Unguarantied); contained *8.8* percent crude protein.

HOTTELET Co., Milwaukee, Wis. Griswold & Mackinnon, St. Johnsbury. ————. Guaranteed to contain *8* percent crude protein; guaranty fulfilled.

LARROWE MILLING Co., Detroit, Mich. E. W. Bailey & Co., Montpelier. Kempton Mills, Barre. J. D. Thompson, Norwich. ————. Guaranteed to contain *8* percent crude protein; guaranty fulfilled.

LARROWE MILLING Co., Detroit, Mich. Burlington Flouring Co., Burlington; E. Crosby & Co., Brattleboro. ————. Guaranteed to contain *8* percent crude protein; guaranty fulfilled.

ALFALFA MEALS

DENVER ALFALFA MILLING & PRODUCTS Co., Hartman, Colo. E. W. Bailey & Co., Montpelier. ————. Guaranteed to contain *12* percent crude protein; guaranty fulfilled.

ALBERT DICKINSON Co., Chicago, Ill. Griswold & Mackinnon, St. Johnsbury. ————. Guaranteed to contain *12* percent crude protein; guaranty fulfilled.

ALBERT DICKINSON Co., Chicago, Ill. E. T. & H. K. Ide, St. Johnsbury. ————. Guaranteed to contain *12* percent crude protein; guaranty fulfilled.

EMPIRE STATE MILLS, Morrisville, N. Y. S. P. Curtis & Son, Rutland. ————. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

KORNFALFA FEED & MILLING Co., Kansas City, Mo. J. H. Hewitt, South Royalton. *Pioneer.* Guaranteed to contain *12* percent crude protein, but failed by one percent to fulfill guaranty.

KORNFALFA FEED & MILLING Co., Kansas City, Mo. J. W. Jones & Co., Burlington. *Pioneer.* Guaranteed to contain *12* percent crude protein; guaranty fulfilled.

M. C. PETERS, Omaha, Neb. J. H. Hewitt, South Royalton. *Lucerne Pure.* Guaranteed to contain *12* percent crude protein; guaranty fulfilled.

PURINA MILLS, St. Louis, Mo. A. H. McLeod Milling Co., St. Johnsbury. ————. Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

OTTO WEISS MILLING Co., Wichita, Kan. Burditt Bros., Rutland. ———— Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

————. E. Crosby & Co., Brattleboro. ————. (Unguarantied); contained *13.1* percent crude protein.

————. H. W. Myers & Son, Inc., Bennington. ————. (Unguarantied); contained *15.8* percent crude protein.

MISCELLANEOUS

E. W. **BAILEY** & Co., Montpelier, Vt. E. W. Bailey & Co., Montpelier. *Corn and Oats Provender.* Contained 10.1 percent crude protein.

BUFFALO CEREAL Co., Buffalo, N. Y. H. S. Buttles' Estate, Brandon. *Mohawk Corn Meal.* Contained 8.3 percent crude protein.

BUFFALO CEREAL Co., Buffalo, N. Y. H. S. Buttles' Estate, Brandon. *Ground White Oats.* Contained 12.3 percent crude protein.

ELMORE MILLING Co., Oneonta, N. Y. E. R. Sheldon, Rupert. *Corn Meal.* Contained 10.1 percent crude protein.

ELMORE MILLING Co., Oneonta, N. Y. E. R. Sheldon, Rupert. *Cracked Corn.* Contained 9.4 percent crude protein.

ELMORE MILLING Co., Oneonta, N. Y. E. R. Sheldon, Rupert. *Kafir.* Contained 10.8 percent crude protein.

H. N. **GRAY**, Cambridge, Vt. H. N. Gray, Cambridge. *Corn and Oats Provender.* Contained 10.8 percent crude protein.

M. C. Co., ————. Burlington Flouring Co., Burlington. *Wheat screenings.* Contained 12.1 percent crude protein.

W. R. **WHITE**, North Bennington, Vt. W. R. White, North Bennington. *Buckwheat Bran.* Contained 21.8 percent crude protein.

W. R. **WHITE**, North Bennington, Vt. W. R. White, North Bennington. *Buckwheat Middlings.* Contained 14.9 percent crude protein.

PROPRIETARY FEEDS

DAIRY, STOCK, HORSE

AMERICAN HOMINY Co., Indianapolis, Ind. E. A. Dutton, East Craftsbury; E. Crosby & Co., Brattleboro. *Homcoline Feed.* Ingredients as stated by manufacturer, "Corn germ meal." Guaranteed to contain *17* percent crude protein; guaranty fulfilled.

AMERICAN MAIZE PRODUCTS Co., New York, N. Y. E. W. Bailey & Co., Montpelier. *Cream of Corn Dairy Feed.* No ingredients stated by manufacturer. (Illegal). Guaranteed to contain *23* percent crude protein; guaranty fulfilled.

ARCADY FARMS' MILLING Co., 208 South LaSalle St., Chicago, Ill. H. S. Buttles' Estate, Brandon. *Arcady Dairy Feed.* Ingredients as stated by manufacturer, "Malt sprouts, brewers' dried grains, cottonseed meal, molasses, oat by-products, ground grain screenings, salt." (Illegal label). Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

ARCADY FARMS' MILLING Co., 208 South LaSalle St., Chicago, Ill. Chaffee Lumber Co., Rutland; Crosby Grain Store, South Londonderry. *Arcady Dairy Feed.* Ingredients as stated by manufacturer, "Malt sprouts, brewers' dried grains, cottonseed meal, molasses, oat by-products, ground grain screenings, salt." (Illegal label). Guaranteed to contain *16* percent crude protein, but failed by a quarter of one percent to fulfill guaranty.

E. W. **BAILEY** & Co., Swanton, Vt. E. W. Bailey & Co., Montpelier; R. P. Webster, Barton. *Pennant Stock Feed; Yellow Tag Stock Feed.* Ingredients as stated by manufacturer, "Fine white hominy and oat by-product." (Illegal label). Guaranteed to contain *10* percent crude protein, but failed by one percent to fulfill guaranty.

E. W. **BAILEY** & Co., Swanton, Vt. E. W. Bailey & Co., Montpelier. *Pennant Stock Feed; Yellow Tag Stock Feed.* Ingredients as stated by manufacturer, "Fine white hominy and oat by-product." (Illegal label). Guaranteed to contain *10* percent crude protein, but failed by nearly a half of one percent to fulfill guaranty.

E. W. **BAILEY** & Co., Montpelier, Vt. Clark & Devine, Northfield; L. L. Marsh, Enosburg Falls; E. I. Benson, Woodstock. *Pennant Stock Feed; Yellow Tag Stock Feed.* Ingredients as stated by manufacturer, "Fine white hominy and oat by-product." (Illegal label). Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

BOUTWELL MILLING & GRAIN Co., Troy, N. Y. G. W. Rose, Middlebury. *Boutwell's Rye Feed.* Ingredients as stated by manufacturer; not given.

(This is possibly an unmixed by-product from the manufacture of rye flour). Guaranteed to contain *12.5* percent crude protein; guaranty fulpercent to fulfill guaranty.

BURLINGTON FLOURING Co., Burlington, Vt. Burlington Flouring Co., Burlington. *Perfection Dairy (No. 1) Feed.* Ingredients as stated by manufacturer, "Cottonseed meal, old process linseed meal, dried brewers' grains, dried beet pulp, gluten feed, hominy, wheat middlings, wheat flour, wheat bran and salt." Guaranteed to contain *26* percent crude cent crude protein; guaranty fulfilled.

BURLINGTON FLOURING Co., Burlington, Vt. Burlington Flouring Co., Burlington. *Perfection Dairy (No. 3) Feed.* Ingredients as stated by manufacturer, "Cottonseed meal, old process linseed meal, dried brewers' grains, dried beet pulp, gluten feed, hominy, wheat middlings, wheat flour, wheat bran and salt." Guaranteed to contain *22* percent crude guaranty.

BURLINGTON FLOURING Co., Burlington, Vt. Burlington Flouring Co., Burlington. *Burlington Chop Feed.* Ingredients as stated by manufacturer, "Corn meal, rolled or ground oats, ground wheat and wheat screenings, hominy feed and reground oat feed." (Illegal label). Guaranteed to contain *9* percent crude protein; guaranty fulfilled.

CHAPIN & Co., Hammond, Ind. Griswold & Mackinnon, St. Johnsbury, Vt. *Unicorn Dairy Ration.* Ingredients as stated by manufacturer, "Corn distillers' grains, cottonseed meal, linseed meal, hominy meal, gluten feed, cornstarch by-products with corn bran, barley feed, malt sprouts, brewers' grains and pure wheat bran." Guaranteed to contain *28* percent crude protein, but failed by one and one-half percent to fulfill protein; guaranty fulfilled.

CHAPIN & Co., Hammond, Ind. R. L. Clark, Barre; Davis Feed Co., Rutland; C. M. McFarland & Son, Barton; A. G. Spaulding, Ludlow. *Unicorn Dairy Ration.* Ingredients as stated by manufacturer, "Corn distillers' grains, cottonseed meal, linseed meal, hominy meal, gluten feed, cornstarch by-products with corn bran, barley feed, malt sprouts, brewers' grains and pure wheat bran." Guaranteed to contain *26* percent crude protein, but failed by a third of one percent to fulfill guaranty.

CHAPIN & Co., Hammond, Ind. D. H. McHugh, Middlebury; C. M. McFarland & Son, Barton; Chas. M. Seaver, Williamstown; J. D. Thompson, Norwich. *Unicorn Dairy Ration.* Ingredients as stated by manufacturer, "Corn distillers' grains, cottonseed meal, linseed meal, hominy meal, gluten feed, cornstarch by-products with corn bran, barley feed, malt sprouts, brewers' grains and pure wheat bran." Guaranteed to contain *26* perprotein; guaranty fulfilled.

CHAPIN & Co., Hammond, Ind. J. E. Hunt & Co., Jeffersonville; E. I. Benson, Woodstock. *Lactola Dairy Feed.* Ingredients as stated by manufacturer, "Choice cottonseed meal, corn distillers' grains, clipped oat by-product, corn gluten feed, corn germ meal, brewers' dried grains, ivory nut meal, cane molasses, salt." (Illegal label). Guaranteed to contain *16.5* percent crude protein; guaranty fulfilled.

CITY FEED Co., St. Albans, Vt. City Feed Co., St. Albans. *Farmers' Favorite Ration Feed.* Ingredients as stated by manufacturer, "Cottonseed meal, Buffalo gluten, malt sprouts, distillers' grains, bran, hominy or corn meal, linseed and salt not over 0.75 percent." Guaranteed to contain *25.5* percent crude protein; guaranty fulfilled.

CITY FEED Co., St. Albans, Vt. City Feed Co., St. Albans. *Farmers' Favorite Ration Feed.* Ingredients as stated by manufacturer, "Cottonseed meal, Buffalo gluten, malt sprouts, distillers' grains, bran, hominy or corn meal, linseed and salt not over 0.75 percent." Guaranteed to contain *25.5* percent crude protein, but failed by nearly one and three-fourths filled.

CLOVER LEAF MILLING Co., Buffalo, N. Y. C. E. Miller, Wells River; C. O. Fowler, North Troy; E. W. Bixby & Son, Poultney; H. E. Shaw, Stowe. *Clover Leaf Dairy Feed.* Ingredients as stated by manufacturer, "Cottonseed meal, corn gluten feed, mixed broken grains consisting of wheat, corn, barley, flax, speltz, ground grain screenings, cocoa shell meal, clipped oat by-product, molasses and a small percentage of salt." (Illegal label). Guaranteed to contain *16.5* percent crude protein; guaranty fulfilled.

CLOVER LEAF MILLING Co., Buffalo, N. Y. Griswold & Mackinnon, St. Johnsbury; Jones & Berry, Montpelier; F. N. Sherman & Son, Newport. *Clover Leaf Dairy Feed.* Ingredients as stated by manufacturer, "Cottonseed meal, corn gluten feed, mixed broken grains consisting of wheat, corn, barley, flax, speltz, ground grain screenings, cocoa shell meal, clipped oat by-product, molasses and a small percentage of salt." (Illegal label). Guaranteed to contain *16.5* percent crude protein; guaranty fulfilled.

CLOVER LEAF MILLING Co., Buffalo, N. Y. C. M. McFarland, & Son, Barton. *Peerless Horse Feed.* Ingredients as stated by manufacturer, "Cracked corn, crushed oats, alfalfa meal, molasses and a small percentage of salt." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

COMMERCIAL MILLING Co., Detroit, Mich. Star Feed Store, Burlington. *Henkel's Chop Feed.* Ingredients as stated by manufacturer, "Corn meal, rye and oat middlings, oats and oat hulls." Guaranteed to contain *8.5* percent crude protein, but failed by about one-quarter of one percent to fulfill guaranty.

CORNO MILLS, St. Louis, Mo. F. P. Edgerton, Wallingford. *Corno Horse and Mule Feed.* Ingredients as stated by manufacturer, "Ground alfalfa, ground corn, cottonseed meal, hominy feed, oat feed." (Illegal label). Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

CHAS. M. COX Co., Boston, Mass. Mathews & Hall, Orleans; A. N. Washburn, Bethel. *Wirthmore Balanced Ration for Milch Cows.* Ingredients as stated by manufacturer, "Cottonseed meal, gluten feed, linseed meal, brewers' grains, malt sprouts, distillers' grains, bran, and hominy or corn meal, 0.75 percent salt." Guaranteed to contain *25.5* percent crude protein; guaranty fulfilled.

CHAS. M. COX Co., Boston, Mass. E. T. Seabury Estate, Waterbury; City Feed Co., St. Albans; G. W. Marble, Woodstock; Swerdfeger & Davis, Marshfield; R. L. Clark, Barre. *Wirthmore Stock Feed for Milch Cows.* Ingredients as stated by manufacturer, "Ground barley, ground oats, ground hominy meal, ground corn and oatmeal mill by-products (oat middlings, oat shorts and oat hulls) and 0.5 percent salt." Guaranteed to contain *9* percent crude protein; guaranty fulfilled.

CHAS. M. COX Co., Boston, Mass. Jones & Berry, Montpelier; Nelson Bros., Springfield; D. W. Paul, East Berkshire; H. I. Randall, Wolcott. *Wirthmore Stock Feed.* Ingredients as stated by manufacturer, "Ground barley, ground oats, ground hominy meal, ground corn and oatmeal mill by-products (oat middlings, oat shorts and oat hulls) and 0.5 percent salt." Guaranteed to contain *9* percent crude protein; guaranty fulfilled.

E. CROSBY & Co., Brattleboro, Vt. W. C. Ballou, Newfane. *Crosby's Ready Ration.* Ingredients as stated by manufacturer, "Distillery dried grains, cottonseed meal, oil meal, malt sprouts, wheat bran, wheat middlings, hominy feed and 0.5 percent salt." Guaranteed to contain *25* percent crude protein, but failed by nearly a half of one percent to fulfill guaranty.

E. CROSBY & Co., Brattleboro, Vt. E. T. & H. K. Ide, St. Johnsbury. *Crosby's Ready Ration.* Ingredients as stated by manufacturer, "Distillery dried grains, cottonseed meal, oil meal, malt sprouts, wheat bran, wheat middlings, hominy feed and 0.5 percent salt." Guaranteed to contain *25* percent crude protein; guaranty fulfilled.

E. CROSBY & Co., Brattleboro, Vt. Farmers' Exchange, Bradford; E. H. Mason, Randolph; W. F. Cunningham, St. Albans; G. S. Welch, Groton. *Crosby's Special Stock Food.* Ingredients as stated by manufacturer, "Wheat middlings, corn meal, hominy feed, brewers' dried grains, oatmeal mill by-products (oat shorts, oat hulls, oat middlings) and one percent table salt." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

E. CROSBY & Co., Brattleboro, Vt. E. Crosby & Co., Brattleboro. *Crosby's Quality Stock Feed.* No ingredients stated by manufacturer. (Illegal). Guaranteed to contain *9* percent crude protein; guaranty fulfilled.

DEWEY BROS. Co., Blanchester, O. C. E. Miller, Wells River. *Dewey's Ready Ration.* Ingredients as stated by manufacturer, "Eagle distillers' dried grains, linseed oil meal, cottonseed meal, malt sprouts, wheat bran, wheat middlings, hominy feed and 0.5 percent salt." Guaranteed to contain *25* crude protein, but failed by one-third of one percent to fulfill guaranty.

DEWEY BROS. Co., Blanchester, O. C. E. Miller, Wells River; F. D. Lapelle & Co., Swanton; E. T. Seabury Estate, Waterbury; Charlotte Feed Co., Charlotte. *Dewey's Ready Ration.* Ingredients as stated by manufacturer, "Eagle distillers' dried grains, linseed oil meal, cottonseed meal, malt sprouts, wheat bran, wheat middlings, hominy feed and 0.5 percent salt." Guaranteed to contain *25* percent crude protein; guaranty fulfilled.

DEWEY BROS. Co., Blanchester, O. Half Century Store Co., Randolph. *Dewey's Stock Feed.* Ingredients as stated by manufacturer, "Wheat feeds, rye middlings, oat meal, 0.5 percent salt." (Illegal). Guaranteed to contain *11* percent crude protein; guaranty fulfilled.

ELMORE MILLING Co., Oneonta, N. Y. S. Sherman & Son, Inc., Poultney. *Elmore Milk Grains.* Ingredients as stated by manufacturer, "Corn distillers' dried grains, old process linseed meal, cottonseed meal, gluten feed, hominy meal, choice wheat bran, barley, malt sprouts, dried brewers' grains, a little fine table salt." Guaranteed to contain *25* percent crude protein; guaranty fulfilled.

FEDERAL MILLING Co., Lockport, N. Y. H. Waite & Son, Morrisville. *Lucky Oat Corn Feed.* Ingredients as stated by manufacturer, "Half oats, half corn, hominy feed, crushed oats, cracked corn, corn feed meal." Guaranteed to contain *9* percent crude protein; guaranty fulfilled.

D. H. GRANDIN MILLING Co., Jamestown, N. Y. H. M. Brown, Castleton. *Grandin's Stock Feed.* Ingredients as stated by manufacturer, "Oats, corn, hominy feed, oat hulls, corn oil meal, gluten and salt." A varient of this statement reads "oats, corn, barley, barley middlings, hominy feed, oat hulls, salt." Guaranteed to contain *8.5* percent crude protein; guaranty fulfilled.

D. H. GRANDIN MILLING Co., Jamestown, N. Y. Davis Feed Co., Rutland. *Grandin's Stock Feed.* Ingredients as stated by manufacturer, "Oats, corn, hominy feed, oat hulls, corn oil meal, gluten and salt." A varient of this statement reads "oats, corn, barley, barley middlings, hominy feed, oat hulls, salt." Guaranteed to contain *8.5* percent crude protein, but failed by nearly a quarter of one percent to fulfill guaranty.

GRISWOLD & MACKINNON, St. Johnsbury, Vt. Griswold & Mackinnon, St. Johnsbury. *Xtra Good Stock Feed.* Ingredients as stated by manufacturer, "Corn, barley, hominy feed, wheat flour, puffed rice and wheat, oat meal mill by-product (oat middlings, oat hulls, oat shorts), middlings with screenings not exceeding mill-run, cottonseed meal, 0.5 percent salt." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

H. O. Co., Buffalo, N. Y. Guild Grain Co., Ludlow. *H. O. Co.'s Algrane Milk Feed.* Ingredients as stated by manufacturer. "Oat hulls, wheat middlings, gluten feed, corn, cottonseed meal, oats, oat shorts, salt." Guaranteed to contain *14* percent crude protein; guaranty fulfilled.

H. O. Co., Buffalo, N. Y. S. Sherman & Son, Inc., Poultney. *H. O. Co.'s Algrane Horse Feed.* Ingredients as stated by manufacturer, "Oats, oat shorts, ground corn, oat hulls, middlings, hominy, gluten, molasses and 0.5 percent salt." Guaranteed to contain *11* percent crude protein; guaranty fulfilled.

H. O. Co., Buffalo, N. Y. S. Sherman & Son, Inc., Poultney. *H. O. New England Stock Feed.* Ingredients as stated by manufacturer, "Wheat middlings, ground corn, hominy, oat meal, ground screenings, molasses and 0.5 percent salt." Guaranteed to contain *9* percent crude protein; guaranty fulfilled.

H. O. Co., Buffalo, N. Y. S. Sherman & Son, Inc., Poultney. *H. O. Co.'s De-Fi Feed.* Ingredients as stated by manufacturer, "Oat hulls, ground corn, hominy feed, wheat middlings, oat middlings, oat shorts, ground grain screenings, molasses and 0.5 percent salt." Guaranteed to contain *8* percent crude protein; guaranty fulfilled.

W. H. HASKELL & Co., Toledo, O. R. L. Clark, Barre. *Haskell's Stock Feed.* Ingredients as stated by manufacturer, "Ground corn, ground oats, hominy feed, oat hulls, oat shorts and salt." Guaranteed to contain *8* cent crude protein; guaranty fulfilled.

J. H. HEWITT, South Royalton, Vt. J. H. Hewitt, South Royalton. *Our Stock Feed.* Ingredients as stated by manufacturer, "Hominy and oat feed or regrounds." (Illegal label). Guaranteed to contain *8* percent crude protein; guaranty fulfilled.

INTERNATIONAL SUGAR FEED Co., Minneapolis, Minn. J. E. Foster, Underhill; W. R. White, North Bennington. *International Special Dairy Feed.* Ingredients as stated by manufacturer, "Cottonseed meal, molasses, ground recleaned grain screenings, ground clipped oat by-product, salt." (Illegal label). Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

LARROWE MILLING Co., Detroit, Mich. Burditt Bros., Ludlow; Burditt Bros., Rutland; C. S. Richmond, Northfield. *Larro-Feed-Ready Ration.* Ingredients as stated by manufacturer, "Cottonseed meal, corn gluten feed, dried distillers' grains (mainly from corn), dried beet pulp, standard wheat bran, standard wheat middlings and 0.75 percent salt. Wheat bran and wheat middlings may contain ground screenings not exceeding mill-run." Guaranteed to contain *20* percent crude protein, but failed by a little more than one-half of one percent to fulfill guaranty.

LARROWE MILLING Co., Detroit, Mich. Richmond & Son, Northfield; G. W. Rose, Middlebury. *Larro-Feed-Ready Ration.* Ingredients as stated by manufacturer, "Cottonseed meal, corn gluten feed, dried distillers' grains (mainly from corn), dried beet pulp, standard wheat bran, standard wheat middlings and 0.75 percent salt. Wheat bran and wheat middlings may contain ground screenings not exceeding mill-run." Guaranteed to contain *19* percent crude protein; guaranty fulfilled.

MAYFLOWER MILLS, Fort Wayne, Ind. Vermont Cereal Co., Burlington, Vt. Richmond & Son, Northfield; Frank Amsden, Greensboro Bend. *Waumbeck Milk Makers' Mixture.* Ingredients as stated by manufacturer, "Dried malted grains, old process oil meal, cottonseed meal, pulverized grain screenings, 0.5 percent salt added." Guaranteed to contain *23* perpercent crude protein; guaranty fulfilled.

R. H. MCEWEN MILLING Co., Ogdensburg, N. Y. John Burdick, Wallingford. *Pontiac Dairy Ration.* Ingredients as stated by manufacturer, "Distillers' dried grains, malt sprouts, hominy meal, cottonseed meal, linseed meal, wheat bran and 0.5 percent salt." Guaranteed to contain *24* percent crude protein; guaranty fulfilled.

NATIONAL OATS Co., St. Louis, Mo. F. C. Jennison, Sheldon. *Pawnee Cow Feed.* Ingredients as stated by manufacturer, "Hominy feed, cottonseed meal, ground grain screenings and oat feed." (Illegal label). Guaranteed to contain *15* percent crude protein; guaranty fulfilled.

NOWAK MILLING CORPORATION, Buffalo, N. Y. S. P. Curtis & Son, Rutland. *Justice Stock Feed.* Ingredients as stated by manufacturer, "Ground oats, corn feed meal, wheat middlings, oat middlings, oat hulls, clipped oat by-product, ground grain screenings, 0.75 percent salt." (Illegal label). Guaranteed to contain *10* percent crude protein, but failed by nearly 2 percent to fulfill guaranty.

NOWAK MILLING CORPORATION, Buffalo, N. Y. S. P. Curtis & Son, Rutland. *Pure Mo-Lene Horse Feed.* Ingredients as stated by manufacturer, "Cracked corn, crushed oats, whole oats, ground alfalfa, molasses, 0.75 percent salt." Guaranteed to contain *9* percent crude protein; guaranty fulfilled.

PILLIOD MILLING Co., Swanton, O. J. W. Gillis, Danville. *Waumbeck Butter-Fat Meal.* Ingredients as stated by manufacturer, "Cottonseed meal, old process oil meal, ground wheat, ground screenings." Guaranteed to contain *24* percent crude protein, but failed by more than 4 percent to fulfill guaranty.

PURINA MILLS, Buffalo, N. Y. W. C. Marsh, Sheldon; H. A. Slayton & Co., Morrisville. *Protena Dairy Feed.* Ingredients as stated by manufacturer, "Cottonseed meal, brewers' dried grains, clipped oat by-product, ground wheat screenings, molasses and one percent salt." (Illegal label). Guaranteed to contain *16.5* percent crude protein, but failed by almost one and three-fourths percent to fulfill guaranty.

PURINA MILLS, Buffalo, N. Y. H. A. Slayton & Co., Morrisville. *Protena Dairy Feed.* Ingredients as stated by manufacturer, "Cottonseed meal, brewers' dried grains, clipped oat by-product, ground wheat screenings, molasses and one percent salt." (Illegal label). Guaranteed to contain *16.5* percent crude protein, but failed by more than one and one-half percent to fulfill guaranty.

PURITY OATS Co., Davenport, Ia. A. G. Spaulding, Ludlow. *Iowa Dairy Feed.* Ingredients as stated by manufacturer, "Cottonseed meal, corn meal, hominy feed, brewers' dried grains, oat meal mill by-product (oat shorts, oat hulls, oat middlings), and one percent table salt." Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

PURITY OATS Co., Davenport, Ia. Griswold & Mackinnon; J. G. Turnbull & Co., Orleans. *Iowa Stock Feed.* Ingredients as stated by manufacturer, "Wheat middlings, corn middlings, hominy feed, brewers' dried grains, oat meal mill by-products (oat shorts, oat hulls, oat middlings), and one percent table salt." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

PURITY OATS Co., Davenport, Ia. Geo. J. Stannard, Fair Haven; Griswold & Mackinnon, St. Johnsbury. *Iowa Stock Feed.* Ingredients as stated by manufacturer, "Wheat middlings, corn middlings, hominy feed, brewers' dried grains, oat meal mill by-products (oat shorts, oat hulls, oat middlings) and one percent table salt." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

PURITY OATS Co., Davenport, Ia. Clark & Devine, Northfield. *Purity Oat Feed.* Ingredients not stated by manufacturer. Illegal. Guaranteed to contain *6.73* percent crude protein; guaranty fulfilled.

QUAKER OATS Co., Chicago, Ill. Geo. Shorey, Lyndonville; Half Century Store Co., Randolph. *Blue Ribbon Dairy Feed.* Ingredients as stated by manufacturer, "Cottonseed meal, malt sprouts, molasses, hominy, new process linseed oil meal, oatmeal mill by-product (oat middlings, oat hulls, oat shorts), bran with screenings not exceeding the mill-run." Guaranteed to contain *25* percent crude protein, but failed by nearly one and one-half percent to fulfill guaranty.

QUAKER OATS Co., Chicago, Ill. J. E. Hunt & Son, Jeffersonville. *Quaker Dairy Feed.* Ingredients as stated by manufacturer, "Molasses, malt sprouts, cottonseed meal, ground screenings, linseed meal, oatmeal mill by-product (oat middlings, oat hulls, oat shorts)." Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

QUAKER OATS Co., Chicago, Ill. J. R. Madigan, Burlington. *Quaker Dairy Feed.* Ingredients as stated by manufacturer, "Molasses, malt sprouts, cottonseed meal, ground screenings, linseed meal, oatmeal mill by-product (oat middlings, oat hulls, oat shorts)." Guaranteed to contain *16* percent crude protein, but failed by one and one-half percent to fulfill guaranty.

QUAKER OATS Co., Chicago, Ill. S. Sherman & Son, Poultney. *Quaker Dairy Feed with Molasses.* Ingredients as stated by manufacturer, "Molasses, malt sprouts, cottonseed meal, ground screenings, linseed meal, oatmeal mill by-product (oat middlings, oat hulls, oat shorts)." Guaranteed to contain *16* percent crude protein, but failed by more than one-half of one percent to fulfill guaranty.

QUAKER OATS Co., Chicago, Ill. S. P. Curtis & Son, Rutland. *Green Cross Horse Mixed Feed.* Ingredients as stated by manufacturer, "Alfalfa meal, ground corn, crushed oats, molasses, cottonseed meal, oatmeal mill by-product (oat middlings, oat hulls, oat shorts)." Guaranteed to contain *10* percent crude protein, but failed by one-half of one percent to fulfill guaranty.

QUAKER OATS Co., Chicago, Ill. D. H. McHugh, Middlebury. *Green Cross Horse Mixed Feed.* Ingredients as stated by manufacturer, "Alfalfa meal, ground corn, crushed oats, molasses, cottonseed meal, oatmeal mill by-product (oat middlings, oat hulls, oat shorts)." Guaranteed to contain *10* percent crude protein, but failed by nearly a half of one percent to fulfill guaranty.

QUAKER OATS Co., Chicago, Ill. City Feed Co., St. Albans; Miles, McMahon & Son, Stowe; A. B. Kilbourne, Bristol; E. T. & H. K. Ide, St. Johnsbury. *Schumaker's Stock Feed.* Ingredients as stated by manufacturer, "Ground corn, ground barley, hominy feed, wheat flour, wheat middlings with screenings, ground puffed rice, oatmeal mill by-product (oat middlings, hulls, shorts), cottonseed meal, 0.5 percent salt." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

QUAKER OATS Co., Chicago, Ill. E. W. Bailey & Co., Montpelier; E. Crosby & Co., Brattleboro; E. T. & H. K. Ide, St. Johnsbury; F. M. Sherman & Son, Newport. *Schumaker's Stock Feed.* Ingredients as stated by manufacturer, "Ground corn, ground barley, hominy feed, wheat flour, wheat middlings with screenings, ground puffed rice, oatmeal mill by-product (oat middlings, hulls, shorts), cottonseed meal, 0.5 percent salt." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

QUAKER OATS Co., Richford, Vt. L. L. Marsh, Enosburg Falls. *White Diamond Feed.* Ingredients as stated by manufacturer, "Ground corn, hominy feed, oatmeal mill by-products (oat middlings, oat hulls, oat shorts), and 0.5 percent salt." Guaranteed to contain *8* percent crude protein; guaranty fulfilled.

RALSTON-PURINA Co., Buffalo, N. Y. G. W. Rose, Middlebury; G. W. Marble, Woodstock; R. P. Webster, Barton. *Purina Cow-Chow Feed.* Ingredients as stated by manufacturer, "Cottonseed meal, gluten feed, brewers' dried grains, molasses, ground alfalfa and one percent salt." Guaranteed to contain *24* percent crude protein; guaranty fulfilled.

RALSTON-PURINA Co., Buffalo, N. Y. H. A. Slayton & Co., Morrisville; A. H. McLeod Milling Co., St. Johnsbury. *Protena Dairy Feed.* Ingredients as stated by manufacturer, "Cottonseed meal, brewers' dried grains, clipped oat by-product, ground wheat screenings, molasses and one percent salt." (Illegal label). Guaranteed to contain *16.5* percent crude protein; guaranty fulfilled.

RALSTON-PURINA Co., St. Louis, Mo. J. W. Jones Co., Burlington; R. P. Webster, Barton; Jones & Berry, Montpelier. *Purina Feed with Molasses.* Ingredients as stated by manufacturer, "Cracked corn, whole oats, ground alfalfa, molasses and one percent salt." Guaranteed to contain *9.3* percent crude protein, but failed by a quarter of one percent to fulfill guaranty.

RALSTON-PURINA Co., INC., Buffalo, N. Y. H. A. Slayton & Co., Morrisville; R. L. Clark, Barre. *Purina Feed with Molasses.* Ingredients as stated by manufacturer, "Cracked corn, whole oats, ground alfalfa, molasses and one percent salt." Guaranteed to contain *9.3* percent crude protein; guaranty fulfilled.

RALSTON-PURINA Co., St. Louis, Mo. Jones & Berry, Montpelier; R. P. Webster, Barton. *Purina Sweet Feed.* Ingredients as stated by manufacturer, "Ground alfalfa, molasses and one percent salt." Guaranteed to contain *9* percent crude protein; guaranty fulfilled.

RALSTON-PURINA Co., INC., Buffalo, N. Y. A. H. McLeod Milling Co., St. Johnsbury. *Purina Sweet Feed.* Ingredients as stated by manufacturer, "Ground alfalfa, molasses and one percent salt." Guaranteed to contain *9* percent crude protein; guaranty fulfilled.

RALSTON-PURINA Co., INC., Buffalo, N. Y. Burditt Bros., Brandon. *Purina Sweet Feed.* Ingredients as stated by manufacturer, "Ground alfalfa, molasses and one percent salt." Guaranteed to contain *8* percent crude protein; guaranty fulfilled.

REPUBLIC MILLING Co., East St. Louis, Ill. J. D. Thompson, Norwich. *Supreme Horse Feed.* Ingredients as stated by manufacturer, "Corn, oats, alfalfa, cane molasses, salt." Guaranteed to contain *9* percent crude protein; guaranty fulfilled.

ROBIN HOOD MILLS, LTD., Moosejaw and Calgary, Alberta. F. D. Lapelle & Co., Swanton; Walker & Brock, Barnet. *Oat Feed.* No ingredients stated by manufacturer. (Illegal). Guaranteed to contain *5.25* percent crude protein; guaranty fulfilled.

DAVID STOTT MILLING CO., Detroit, Mich. H. C. Skeels & Co., Swanton. *Winner Chop Feed.* No ingredients stated by manufacturer. (Illegal). Guaranteed to contain *8* percent crude protein; guaranty fulfilled.

THOMPSON MILLING CO., Lockport, N. Y. S. Sherman & Son, Inc., Poultney. *Elmore Stock Feed.* Ingredients as stated by manufacturer, "Corn meal, hominy, dried brewers' grains, wheat bran, oatmeal mill by-product (oat middlings, oat shorts, oat hulls), salt." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

UBIKO MILLING CO., Cincinnati, O. E. W. Bailey & Co., Montpelier; Burditt Bros., Ludlow; S. P. Curtis & Son, Rutland; A. H. McLeod Milling Co., St. Johnsbury; F. M. Sherman & Son, Newport. *Union Grains; Biles' Ready Ration.* Ingredients as stated by manufacturer, "Fourex distillers' dried grains, choice cottonseed meal, old process linseed meal, white wheat middlings, winter wheat bran, hominy meal, brewers' dried grains, barley malt sprouts, 0.5 percent fine table salt and nothing else." Guaranteed to contain *24* percent crude protein; guaranty fulfilled.

UBIKO MILLING CO., Cincinnati, O. Chas. M. Seaver, Williamstown; Miles, McMahon & Son, Stowe; L. L. Marsh, Enosburg Falls; E. T. & H. K. Ide, St. Johnsbury; A. B. Kilbourne, Bristol. *Union Grains; Biles' Ready Ration.* Ingredients as stated by manufacturer, "Fourex distillers' dried grains, choice cottonseed meal, old process linseed meal, white wheat middlings, winter wheat bran, hominy meal, brewers' dried grains, barley malt sprouts, 0.5 percent fine table salt and nothing else." Guaranteed to contain *24* percent crude protein; guaranty fulfilled.

VERMONT CEREAL CO., Burlington, Vt. Gregory Grain Co., Burlington. *Waumbeck Stable Feed.* Ingredients as stated by manufacturer, "Corn meal, rye and oat middlings, oats and oat hulls." Guaranteed to contain *8* percent crude protein; guaranty fulfilled.

R. P. WEBSTER, Barton, Vt. R. P. Webster, Barton. *Ray's Ready Ration.* Ingredients as stated by manufacturer, "Distillers' grain, bran, malt sprouts, gluten, cottonseed meal, molasses feed, linseed oil meal, 0.5 percent salt." (Illegal label). Guaranteed to contain *25* percent crude protein, but failed by nearly one percent to fulfill guaranty.

WESTERN GRAIN PRODUCTS CO., Hammond, Ind. City Feed Co., St. Albans, Vt. E. T. & H. K. Ide, St. Johnsbury. *Hammond Dairy Feed.* Ingredients as stated by manufacturer, "Cottonseed meal, corn distillers' grains, malt sprouts, ground clipped oat by-product, ground grain screenings, molasses and salt." (Illegal label). Guaranteed to contain *16.5* percent crude protein; guaranty fulfilled.

WESTERN GRAIN PRODUCTS CO., Hammond, Ind. E. T. & H. K. Ide, St. Johnsbury; MacDiarmid & Co., Newport. *Hammond Dairy Feed.* Ingredients as stated by manufacturer, "Cottonseed meal, corn distillers' grains, malt sprouts, ground clipped oat by-product, ground grain screenings, molasses and salt." (Illegal label). Guaranteed to contain *16.5* percent crude protein; guaranty fulfilled.

XTRA VIM MOLASSES FEED CO., Boston, Mass. R. L. Clark, Barre; L. L. Marsh, Enosburg Falls. *Xtra Vim Molasses Feed.* Ingredients as stated by manufacturer, "Pure cane sugar molasses, mixed with a small percentage of sphagnum moss." Guaranteed to contain *4.61* percent crude protein, but failed by a half of one percent to fulfill guaranty.

XTRA VIM MOLASSES FEED CO., Boston, Mass. A. B. Kilbourne, Bristol; Sweat-Comings Co., Richford; R. L. Clark, Barre. *Xtra Vim Molasses Feed.* Ingredients as stated by manufacturer, "Pure cane sugar molasses, mixed with a small percentage of sphagnum moss." Guaranteed to contain *4.61* percent crude protein; guaranty fulfilled.

PROPRIETARY FEEDS

CALF

BLATCHFORD'S CALF MEAL FACTORY, Waukegan, Ill. Kempton Mills, Barre; E. R. Sheldon, Rupert; A. H. McLeod Milling Co., St. Johnsbury; F. D. Lapelle & Co., Swanton. *Blatchford's.* Ingredients as stated by manufacturer, "Locust bean meal, unpressed flaxseed, wheat flour, barley meal, ground beans and peas, rice polish, old process oil meal, cocoa shell meal, cocoanut meal, recleaned cottonseed meal, fenugreek, dried milk, anise and salt." Guaranteed to contain *24* percent crude protein; guaranty fulfilled.

BLATCHFORD'S CALF MEAL FACTORY, Waukegan, Ill. John Burdick, Wallingford; E. W. Bailey & Co., Montpelier; H. Sturtevant, E. Fairfield. *Blatchford's.* Ingredients as stated by manufacturer, "Locust bean meal, unpressed flaxseed, wheat flour, barley meal, ground beans and peas, rice polish, old process oil meal, cocoa shell meal, cocoanut meal, recleaned cottonseed meal, fenugreek, dried milk, anise and salt." Guaranteed to contain *24* percent crude protein, but failed by one-third of one percent to fulfill guaranty.

QUAKER OATS CO., Chicago, Ill. W. V. Phelps, Enosburg Falls. *Schumaker's.* Ingredients as stated by manufacturer, "Oatmeal, wheat meal, dried casein, ground flaxseed, cottonseed meal and not to exceed *0.5* percent bicarbonate of soda." Guaranteed to contain *19* percent crude protein, but failed by one-third of one percent to fulfill guaranty.

QUAKER OATS CO., Chicago, Ill. C. M. McFarland & Son, Barton. *Schumaker's.* Ingredients as stated by manufacturer, "Oatmeal, wheat meal, dried casein, ground flaxseed, cottonseed meal and not to exceed 0.5 percent bicarbonate of soda." Guaranteed to contain *19* percent crude protein, but failed by one-third of one percent to fulfill guaranty.

RYDE & CO., Chicago, Ill. Mathews & Hall, Orleans. *Ryde's Cream.* Ingredients as stated by manufacturer, "Fenugreek, anise seed, cottonseed meal, wheat flour, flaxseed meal, carob beans, bean meal, lentils, cocoa shells and salt." Guaranteed to contain *25* percent crude protein; guaranty fulfilled.

RYDE & CO., Chicago, Ill. Bradford Mills, Bradford. *Ryde's Cream.* Ingredients as stated by manufacturer, "Fenugreek, anise seed, cottonseed meal, wheat flour, flaxseed meal, carob beans, bean meal, lentils, cocoa shells and salt." Guaranteed to contain *25* percent crude protein; guaranty fulfilled.

PROPRIETARY FEEDS

POULTRY

ANIMAL MEAL, MEAT SCRAPS, ETC.

BEACH SOAP CO., Lawrence, Mass. Half Century Store Co., Randolph. *Star Bone and Meat Meal.* Ingredients as stated by manufacturer, "Bone and meat meal." Guaranteed to contain — percent crude protein; guaranty fulfilled.

JOS. BRECK & SONS, Boston, Mass. E. T. Seabury Estate, Waterbury; Mathews & Hall, Orleans. *Ground Beef Scraps.* Ingredients as stated by manufacturer, "Ground beef scraps." Guaranteed to contain *43* percent crude protein; guaranty fulfilled.

JOS. BRECK & SONS, Boston, Mass. E. T. Seabury Estate, Waterbury. *Ground Beef Scraps.* Ingredients as stated by manufacturer, "Ground beef scraps." Guaranteed to contain *48* percent crude protein, but failed by three and one-half percent to fulfill guaranty.

BURLINGTON RENDERING CO., Burlington, Vt. Chas. M. Seaver, Williamstown; E. T. & H. K. Ide, Bradford; Half Century Store Co., Randolph; W. R. White, N. Bennington. *Burlington Poultry Food.* Ingredients as stated by manufacturer, "Cooked meat and bone scraps." Guaranteed to contain *40* percent crude protein; guaranty fulfilled.

BURLINGTON RENDERING Co., Burlington, Vt. Bradford Mills, Bradford; S. P. Curtis & Son, Rutland. *Burlington Poultry Food.* Ingredients as stated by manufacturer, "Cooked meat and bone scraps." Guaranteed to contain *40* percent crude protein; guaranty fulfilled.

BURLINGTON RENDERING Co., Burlington, Vt. A. M. Washburn, Bethel. *Cracked Bone.* Ingredients as stated by manufacturer, "Cracked bone." Guaranteed to contain *20* percent crude protein; guaranty fulfilled.

INTERNATIONAL GLUE Co., Boston, Mass. L. L. Marsh, Enosburg Falls; E. T. & H. K. Ide, St. Johnsbury. *Red Star Fish Scraps.* Ingredients as stated by manufacturer. Not stated. Illegal. Guaranteed to contain *45* percent crude protein, but failed by three and one-fourth percent to fulfill guaranty.

WHITMAN & PRATT RENDERING Co., Lowell, Mass. Griswold & Mackinnon, St. Johnsbury. *Whitman & Pratt Beef Scraps.* Ingredients as stated by the manufacturer, "Beef scraps." Guaranteed to contain *45* percent crude protein; guaranty fulfilled.

MASHES

BLATCHFORD'S CALF MEAL FACTORY, Waukegan, Ill. J. E. Foster, Underhill. *Blatchford's Milk Mash.* Ingredients as stated by manufacturer, "Locust bean meal, flaxseed, wheat flour, barley meal, blood flour, ground beans and peas, rice polish, old process linseed meal, cocoa shell meal, cocoanut meal, cottonseed meal, fenugreek, dried milk, anise and salt, bone, corn and oatmeal middlings, beef scraps, fish and powdered limestone." Guaranteed to contain *20* percent crude protein; guaranty fulfilled.

BLATCHFORD'S CALF MEAL FACTORY, Waukegan, Ill. S. P. Curtis & Son, Rutland. *Blatchford's Milk Mash.* Ingredients as stated by manufacturer, "Locust bean meal, flaxseed, wheat flour, barley meal, blood flour, ground beans and peas, rice polish, old process linseed meal, cocoa shell meal, cocoanut meal, cottonseed meal, fenugreek, dried milk, anise and salt, bone, corn and oat meal middlings, beef scraps, fish and powdered limestone." Guaranteed to contain *20* percent crude protein; guaranty fulfilled.

BLATCHFORD'S CALF MEAL FACTORY, Waukegan, Ill. E. T. Seabury Estate, Waterbury. *Blatchford's Fill the Basket Egg Mash.* Ingredients as stated by manufacturer, "Bean, cocoanut, cottonseed, flaxseed, locust bran, linseed oil and pea meals, fenugreek, wheat flour, dried milk, cocoa shells, salt, alfalfa, barley, bone, corn and oat meals, wheat bran, wheat middlings, beef scraps, fish, capsicum and limestone grit." Guaranteed to contain *19* percent crude protein; guaranty fulfilled.

BLATCHFORD'S CALF MEAL FACTORY, Waukegan, Ill. S. P. Curtis & Son, Rutland. *Blatchford's Fill the Basket Egg Mash.* Ingredients as stated by manufacturer, "Bean, cocoanut, cottonseed, flaxseed, locust bran, linseed oil and pea meals, fenugreek, wheat flour, dried milk, cocoa shells, salt, alfalfa, barley, bone, corn and oat meals, wheat bran, wheat middlings, beef scraps, fish, capsicum and limestone grit." Guaranteed to contain *19* percent crude protein; guaranty maintained.

BUFFALO CEREAL Co., Buffalo, N. Y. H. S. Buttles' Estate, Brandon. *Bufceco Laying Mash.* Ingredients as stated by manufacturer, "Ground corn, oats, wheat and kafir corn, wheat bran, wheat middlings, linseed meal, alfalfa meal, oat middlings, meat and bone scraps and 0.5 percent salt." Guaranteed to contain *20* percent crude protein; guaranty fulfilled.

CHAS. M. Cox Co., Boston, Mass. Mathews & Hall, Orleans; Geo. Shorey, Lyndonville. *Wirthmore.* Ingredients as stated by manufacturer, "Ground oats, ground barley, gluten feed, alfalfa meal, wheat bran, ground corn, wheat middlings and about 0.75 percent salt." Guaranteed to contain *17* percent crude protein; guaranty fulfilled.

CHAS. M. Cox Co., Boston, Mass. R. L. Clark, Barre. *Wirthmore.* Ingredients as stated by manufacturer, "Ground oats, ground barley, gluten feed, alfalfa meal, wheat bran, ground corn, wheat middlings and about 0.75 percent salt." Guaranteed to contain *12* percent crude protein; guaranty fulfilled.

GREENE CHICK FEED Co., Marlboro, Mass. R. P. Webster, Barton. *Greene's Five Percent Meat Mash.* Ingredients as stated by manufacturer, "Meat scraps, corn meal, wheat, shell lime, hominy feed, flax screenings, oats, bran, salt." Guaranteed to contain *12* percent crude protein; guaranty fulfilled.

J. H. HEWITT, South Royalton, Vt. J. H. Hewitt, South Royalton. *Our Dry Mash.* Ingredients as stated by manufacturer, "Corn meal, gluten, wheat middlings, wheat bran, linseed meal, alfalfa meal and beef scraps." Guaranteed to contain *12* percent crude protein; guaranty fulfilled.

B. F. HENRY, North Bennington, Vt. B. F. Henry, North Bennington. *Henry's Mash.* Ingredients as stated by manufacturer, "Beef scraps, alfalfa, gluten feed, wheat bran and wheat middlings, corn meal, ground oats, charcoal, salt." Guaranteed to contain *18* percent crude protein; guaranty fulfilled.

A. B. KILBOURNE, Bristol, Vt. A. B. Kilbourne, Bristol. *Dry Mash.* Ingredients as stated by manufacturer, "Alfalfa meal, corn meal, ground oats, wheat bran, wheat middlings, gluten feed, linseed oil meal, meat scraps." Guaranteed to contain *16* percent crude protein; guaranty fulfilled.

PARK & POLLARD Co., Boston, Mass. E. I. Benson, Woodstock; Chas. M. Seaver, Williamstown; J. E. Foster, Underhill; G. W. Rose, Middlebury. *Lay or Bust Dry Mash.* Ingredients as stated by manufacturer, "Wheat bran, wheat middlings, corn, wheat, oats, barley, kafir corn, buckwheat, alfalfa, fish, meat, bone, beet pulp and salt." Guaranteed to contain *18* percent crude protein; guaranty fulfilled.

RALSTON-PURINA Co., St. Louis, Mo. Charlotte Feed Co., Charlotte; R. P. Webster, Barton. *Purina Chicken Chowder.* Ingredients as stated by manufacturer, "Wheat middlings, wheat bran, corn meal, alfalfa meal, linseed meal, granulated meat, charcoal, not over one percent salt." Guaranteed to contain *17* percent crude protein; guaranty fulfilled.

RALSTON-PURINA Co., St. Louis, Mo. Burditt Bros., Rutland, H. A. Slayton & Co., Morrisville. *Purina Chicken Chowder.* Ingredients as stated by manufacturer, "Wheat middlings, wheat bran, corn meal, alfalfa meal, linseed meal, granulated meat, charcoal, not over one percent salt." Guaranteed to contain *18* percent crude protein; guaranty fulfilled.

RALSTON-PURINA Co., St. Louis, Mo. A. H. McLeod Milling Co., St. Johnsbury. *Purina Chicken Chowder.* Ingredients as stated by manufacturer, "Wheat middlings, wheat bran, corn meal, alfalfa meal, linseed meal, granulated meal, not over one percent salt." Guaranteed to contain *12* percent crude protein, but failed by a third of one percent to fulfill guaranty.

RALSTON-PURINA Co., St. Louis, Mo. Charlotte Feed Co., Charlotte. *Purina Chick Feed.* Ingredients as stated by manufacturer, "Wheat, corn, millet, kafir maize." Guaranteed to contain *11* percent crude protein; guaranty fulfilled.

W. R. WHITE, North Bennington, Vt. W. R. White, North Bennington. *Flynn's Dry Mash.* Ingredients as stated by manufacturer, "Wheat bran, wheat middlings, corn meal, ground oats, old process oil meal, gluten, alfalfa, cooked meal or scraps, salt and charcoal." Guaranteed to contain *18* percent crude protein; guaranty fulfilled.

SCRATCH FEEDS

BUFFALO CEREAL Co., Buffalo, N. Y. H. S. Buttles' Estate, Brandon. Iroquois. Ingredients as stated by manufacturer, "Corn, oat, barley, buckwheat, kafir corn, wheat, sunflower seed." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

CHAS. M. COX Co., Boston, Mass. E. T. Seabury Estate, Waterbury; Mathews & Hall, Orleans. *Wirthmore.* Ingredients as stated by manufacturer, "Wheat, kafir corn, sunflower seed, buckwheat, cracked corn, barley, milo maize, oats." Guaranteed to contain *11* percent crude protein; guaranty fulfilled.

E. CROSBY & Co., Brattleboro, Vt. E. Crosby & Co., Brattleboro. *Crosby's Pure.* No ingredients stated by manufacturer. (Illegal). Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

ALBERT DICKINSON Co., Chicago, Ill. A. H. McLeod Milling Co., St. Johnsbury. *Globe.* Ingredients as stated by manufacturer, "Corn, wheat, barley, oats, kafir corn, buckwheat, sunflower, linseed oil cake." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

ALBERT DICKINSON CO., Chicago, Ill. H. B. Sturtevant, East Fairfield. *Pine Tree.* Ingredients as stated by manufacturer, "Corn, wheat, buckwheat, barley, oats, kafir corn, sunflower seed." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

H. O. CO. MILLS, Buffalo, N. Y. Guild Grain Store, Ludlow. *H. O. Co.'s Algrane.* Ingredients as stated by manufacturer, "Wheat, oats, kafir corn, buckwheat, wheat screenings, cracked corn, milo maize, sunflower seed, hulled oats, cracked peas, barley." Guaranteed to contain *11* percent crude protein, but failed by half of one percent to fulfill guaranty.

B. T. HENRY, North Bennington, Vt. B. T. Henry, North Bennington. *Henry's.* Ingredients as stated by manufacturer, "Cracked corn, wheat, oats, buckwheat, barley, kafir corn." Guaranteed to contain *9* percent crude protein; guaranty fulfilled.

E. T. & H. K. IDE, St. Johnsbury, Vt. E. T. & H. K. Ide, Bradford; G. S. Welch, Groton. *Ideal.* Ingredients as stated by manufacturer, "Cracked corn, wheat, kafir corn, oats, buckwheat, barley, sunflower seed." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

E. T. & H. K. IDE, St. Johnsbury, Vt. Bradford Mills, Bradford. *Ideal.* Ingredients as stated by manufacturer, "Cracked corn, wheat, kafir corn, oats, buckwheat, barley, sunflower seed." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

A. B. KILBOURNE, Bristol, Vt. A. B. Kilbourne, Bristol. ————. Ingredients as stated by manufacturer, "Cracked corn, oats, barley, wheat, buckwheat, charcoal and India wheat." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

H. W. MYERS & SON, INC., Bennington, Vt. H. W. Myers & Son, Inc., Bennington. *Green Mountain.* Ingredients as stated by manufacturer, "Cracked corn, wheat, oats, buckwheat, kafir corn, barley and sunflower seed." (Unguarantied). Contained 10.5 percent crude protein.

OSWEGO MILLING CO., Oswego, N. Y. F. D. Lapelle & Co., Swanton. *Pontiac.* Ingredients as stated by manufacturer, "Cracked corn, wheat, barley, buckwheat, oats, kafir corn and milo." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

PARK & POLLARD CO., Boston, Mass. Clark & Devine, Northfield; F. D. Lapelle & Co., Swanton. *Red Ribbon.* Ingredients as stated by manufacturer, "Cracked corn, wheat, buckwheat, barley, kafir corn, oats, milo, sunflower seed." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

PARK & POLLARD CO., Boston, Mass. E. I. Benson, Woodstock; Chas. M. Seaver, Williamstown. *Screened.* Ingredients as stated by manufacturer, "Cracked corn, wheat, buckwheat, barley, oats, kafir corn, milo and sunflower seed." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

PURITY OATS CO., Davenport, Ia. I. H. Carr, Hardwick. *Iowa.* Ingredients as stated by manufacturer, "Cracked corn, wheat, hulled oats, kafir corn, milo maize, barley, recleaned wheat screenings, buckwheat and sunflower seed." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

PURITY OATS CO., Davenport, Ia. MacDiarmid & Co., Newport; Griswold & Mackinnon, St. Johnsbury. *Tom Boy.* Ingredients as stated by manufacturer, "Cracked corn, wheat, hulled oats, kafir corn or milo maize, barley, recleaned wheat screenings, buckwheat and sunflower seed." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

QUAKER OATS CO., Chicago, Ill. Richmond Lumber Co., Richmond; C. O. Fowler, North Troy. *Quaker.* Ingredients as stated by manufacturer, "Whole wheat, kafir corn, barley, cracked corn, buckwheat, sunflower seed." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

QUAKER OATS CO., Chicago, Ill. Bradford Mills, Bradford; A. D. Pease, Burlington. *Quaker.* Ingredients as stated by manufacturer, "Whole wheat, kafir corn, barley, cracked corn, buckwheat, sunflower seed." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

QUAKER OATS Co., Chicago, Ill. Sweat-Comings Co., Richford. *Schumaker's.* Ingredients as stated by manufacturer, "Whole wheat, whole kafir corn, whole barley, cracked Indian corn, whole buckwheat, sunflower seeds." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

QUAKER OATS Co., Chicago, Ill. A. D. Pease, Burlington. *Schumaker's.* Ingredients as stated by manufacturer, "Whole wheat, whole kafir corn, whole barley, cracked Indian corn, whole buckwheat, sunflower seeds." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

PURINA MILLS, St. Louis, Mo. A. H. McLeod Milling Co., St. Johnsbury. *Purina.* Ingredients as stated by manufacturer, "Wheat, corn, barley, kafir corn, milo maize, sunflower and buckwheat." Guaranteed to contain *11* percent crude protein, but failed by one percent to fulfill guaranty.

RALSTON-PURINA Co., Buffalo, N. Y. and St. Louis, Mo. H. A. Slayton & Co., Morrisville; A. H. McLeod Milling Co., St. Johnsbury. *Purina.* Ingredients as stated by manufacturer, "Wheat, corn, barley, kafir corn, milo maize, sunflower and buckwheat." Guaranteed to contain *11* percent crude protein, but failed by a half of one percent to fulfill guaranty.

RALSTON-PURINA Co., Buffalo, N. Y. and St. Louis, Mo. *Protena.* Ingredients as stated by manufacturer, "Wheat, corn, barley, sunflower, kafir corn, milo maize, recleaned grain screenings." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

RALSTON-PURINA Co., Buffalo, N. Y. and St. Louis, Mo. *Winner.* Ingredients as stated by manufacturer, "Wheat, corn, barley, sunflower seed, kafir corn or milo maize, recleaned wheat screenings." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

CHAS. M. COX Co., Boston, Mass. "Griswold & Mackinnon, St. Johnsbury, R. L. Clark, Barre. *Wirthmore Growing Feed.* Ingredients as stated by manufacturer, "Wheat, corn, oats, barley, peas, milo, dried beet pulp, beef scraps, salt." Guaranteed to contain *12* percent crude protein; guaranty fulfilled.

MORRIS BROS., Oneonta, N. Y. E. M. Bixby & Son, Poultney. *Royal Brand Poultry Grains.* Ingredients as stated by manufacturer, "Cracked corn, kafir corn, buckwheat, wheat, oats." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

CARROLL S. PAGE, Hyde Park, Vt. Bradford Mills, Bradford. *Page's Perfected Poultry Food.* Ingredients not stated by manufacturer. (Illegal). Guaranteed to contain *24* percent crude protein; guaranty fulfilled.

PARK & POLLARD Co., Boston, Mass. *P. & P. Growing Feed.* Ingredients as stated by manufacturer, "Ground corn, wheat, barley, oats, meat, bone, alfalfa, kafir corn, wheat bran, wheat middlings, buckwheat, beet pulp, calcium carbonate and salt." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

PARK & POLLARD Co., Boston, Mass. F. D. Lapelle & Co., Swanton. *Intermediate Chick feed.* Ingredients as stated by manufacturer, "Cracked corn, wheat, buckwheat, oats, millet, kafir corn and milo." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

PARK & POLLARD Co., Boston, Mass. L. L. Marsh, Enosburg Falls. *Red Ribbon Chick Feed.* Ingredients as stated by manufacturer, "Cracked corn, cracked wheat, cracked oats, kafir corn, milo maize and whole millet seed." Guaranteed to contain *10* percent crude protein; guaranteed fulfilled.

PARK & POLLARD Co., Boston, Mass. F. D. Lapelle & Co., Swanton. *Margaret Mahaney's Turkey Feed.* Ingredients as stated by manufacturer, "Ground wheat, barley, linseed oil meal, oats, meat, bone, calcium hydroxide, calcium carbonate and salt." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

PORTLAND MILLING Co., Portland, Mich. Half Century Store Co., Randolph. *Champion Chicken Wheat.* (Unguarantied). Contained 10.9 percent crude protein.

QUAKER OATS Co., Chicago, Ill. Bradford Mills, Bradford. *Quaker Chick Feed.* Ingredients as stated by manufacturer, "Cracked wheat, cracked kafir corn, cracked Indian corn, whole millet seed, oat meal, one percent charcoal, wild buckwheat with not to exceed 0.5 percent foul seed. Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

QUAKER OATS CO., Chicago, Ill. S. P. Curtis & Son, Rutland. *Schumaker Little Chick Feed.* Ingredients as stated by manufacturer, "Cracked wheat, cracked kafir corn, cracked Indian corn, millet, oat meal, wild buckwheat, 0.5 percent wild seed, charcoal, marble grit." Guaranteed to contain *10* percent crude protein; guaranty fulfilled.

RALSTON-PURINA CO., Buffalo, N. Y. and St. Louis, Mo. Burditt Bros., Rutland. *Purina Chick Feed.* Ingredients as stated by manufacturer, "Wheat, corn, millet, kafir maize." Guaranteed to contain *11* percent crude protein, but failed by more than one percent to fulfill guaranty.

ROBIN HOOD MILLS, LTD., Moose Jaw and Calgary, Alberta. F. D. Lapelle & Co., Swanton. *Groatlet's Chicken Feed.* Shelled oats. (Unguarantied). Contained 13.8 percent crude protein.

DISCUSSION OF THE RESULTS OF INSPECTION

There were taken 75 samples of the high protein manufacturing by-products (cottonseed, linseed and gluten meals, gluten feeds, distillers' and brewers' dried grains), 37 samples of low protein manufacturing products other than wheat offals (hominy feed, dried beet pulp, alfalfa meal, etc.), 158 samples of wheat offals (brans, middlings, mixed feeds, red dog flour) and 155 samples of proprietary brands, ready mixed rations for horses, cattle and poultry.

It was said in the 1915 bulletin dealing with feeding stuffs inspection that "the character of the feeds sold during the past winter has been excellent. At no time in the 16 years during which the feeding stuff inspection system has been in operation, has so favorable an outcome been secured. Only 12 of 396 samples of goods actually guarantied were deficient; and only 8 of the 12 deficients were one percent short, only 3 were two percent short and there was but a single serious deficiency. * * * * The situation appears to be thoroughly satisfactory so far as the guaranty maintenance is concerned."

The writer regrets that he is not able to announce as satisfactory a result this year or to be so optimistic as to the quality of the feeds farmers have bought in 1916. The outcome has been a distinctly disappointing one. A larger proportion of the feeding stuffs than usual has failed to measure up to the promises made in their behalf. The following tabulation sets forth the situation in concise form; and the annexed discussion goes into details.

	Number of analytical samples	Number of different brands	Protein guaranties range from	Protein contents range from	Guaranty fulfilled within tolerance figures	Guaranty not fulfilled	Unguaranteed
Cottonseed meals	28	16	41 to 37.8	42.5 to 35.8	14	14	..
Linseed meals	12	7	38 to 30	38.8 to 29.8	12	..	..
Gluten meals	1	1	40	47	1	..	..
Gluten feeds	14	9	24 to 23	28.1 to 22.6	14	..	..
Distillers' dried grains.	14	7	31 to 26	33.6 to 26.5	11	3	..
Brewers' dried grains..	6	4	27.2 to 19	30.1 to 17.4	4	2	..
Wheat offals	158	146	18.2 to 11	19.2 to 11.8	123	27	8
Wheat brans	52	50	16.5 to 11	18.4 to 11.8	47	4	1
Wheat middlings ...	44	41	18.2 to 13	17.8 to 14.6	36	6	2
Wheat mixed feeds..	48	41	17 to 12	19.2 to 14.5	34	12	2
Red dog flour........	14	14	17 to 15	17.8 to 13.1	6	5	3
Hominy feeds	12	9	10.4 to 9	11.8 to 9.4	11	1	..
Dried beet pulps	4	3	8	9.2 to 8.8	3	..	1
Alfalfa meals	11	9	14 to 12	18.6 to 10.9	8	1	2
Miscellaneous	10	10			..	..	..
Proprietary feeds	155	116	48 to 4.6	45.8 to 4.1	127	24	4
Dairy, horse, stock..	88	62	26 to 4.6	28.8 to 4.1	69	18	1
High protein	23	17	26 to 20	28.8 to 19.4	17	6	..
Medium protein ...	18	10	19 to 16	22.1 to 14.5	14	4	..
Low protein	47	35	14 to 4.6	14.9 to 4.1	38	8	1
Calf meals	6	3	25 to 19	27.4 to 18.6	6	..	..
Poultry	61	51	48 to 9	45.8 to 9.6	52	6	3
Animal meals	8	6	48 to 20	45.8 to 25.4	6	2	..
Mashes	16	13	20 to 11	23.9 to 11.6	16	..	..
Scratch feeds	24	20	11 to 9	11.6 to 10.1	20	3	1
Chick feeds, etc...	13	12	24 to 10	24.6 to 9.6	10	1	2
Totals	425	337			328	72	15

The situation is yet more concisely set forth as follows:

Cottonseed meals. Half the cottonseed meal samples were not what they were represented to be in respect to their protein contents.

Dried distillers' grains. A fifth of the distillers' dried grains were similarly deficient.

Brewers' dried grains. A third of the brewers' dried grains were similarly deficient.

Wheat feeds. One-sixth of the wheat feeds were not as good as they were said to be in protein, the so-called "mixed feeds" and low grade or red dog feeding flour being particularly deficient.

Proprietary feeds. (*Dairy, horse, stock*). One-fifth of the brands were lacking in protein, poorer than they were said to be by their manufacturers.

Proprietary feeds. (*Poultry*). One-tenth of the brands were lacking in protein, poorer than they were said to be by their manufacturers.

The grand total. One in six of the brands offered for sale in the winter of 1915-16 was short of its protein promise. This is the worst outcome since the law has been on our statute books. Vermont buyers of feeds have been paying higher prices than heretofore and getting poorer goods.

In the following cases divergence between protein promise and fulfillment seems to be excessive.

F. W. Brodé & Co., Memphis, Tenn.
  Owl Cottonseed Meal........Guaranty 41%. Analysis 37.7%.
  Owl Cottonseed Meal........Guaranty 41%. Analysis 36.1%.
Humphreys, Godwin Co., Memphis, Tenn.
  Bull Brand Cottonseed Meal..Guaranty 41%. Analysis 37.4%.
C. L. Montgomery & Co., Memphis, Tenn.
  Canary Brand Cottonseed Meal,
    Guaranty 38.63%. Analysis 35.7%.
J. E. Soper Co., Boston, Mass.
  Pioneer Brand Cottonseed Meal,
    Guaranty 41%. Analysis 37.9%.
Ajax Milling & Feed Co., New York, N. Y.
  Ajax Flakes ....Guaranty 30%. Analysis 28.4%.
Ubiko Milling Co., Cincinnati, O.
  Fourex Distillers' Grains.....Guaranty 30%. Analysis 28.2%.
Atlantic Export Co., Chicago, Ill.
  Brewers' Dried Grains.......Guaranty 25%. Analysis 21.3%.
Fleischmann Co., Chicago, Ill.
  Fleischmann's Brewers' Dried Grains,
    Guaranty 19%. Analysis 17.4%.
Kornfalfa Feed Milling Co., Kansas City, Mo.
  Pioneer Alfalfa Meal........Guaranty 12%. Analysis 10.9%.
Pilloid Milling Co., Swanton, O.
  Waumbeck Butter Fat Meal..Guaranty 24%. Analysis 19.8%.
City Feed Co., St. Albans, Vt.
  Farmers' Favorite Ration Feed,
    Guaranty 25.5%. Analysis 23.8%.
Ralston-Purina Co., St. Louis, Mo.
  Protena Dairy Feed........Guaranty 16.5%. Analysis 14.8%.
Quaker Oats Co., Chicago, Ill.
  Quaker Dairy Feed..........Guaranty 16%. Analysis 14.5%.
E. W. Bailey & Co., Montpelier, Vt.
  Yellow Tag Pennant Stock Feed..Guaranty 10%. Analysis 9%.

Nowak Milling Corp., Buffalo, N. Y.

Justice Stock Feed............Guaranty 10%. Analysis 8.1%.

There were eight wheat offals which failed by large margins to meet their maker's guaranties. The facts are set forth in the tables on pages 17 to 25. In view of the fact that the Vermont law does not require these feeds to be guarantied it seems inadvisable specially to mention them at this point.

CONCERNING THE READY MIXED GOODS

These goods are widely advertised and widely used. Many of them are made from standard feeding stuffs; many contain material of low feeding value. Each package proclaims its contents, so that he who runs may read—if he will.

Let us next compare the prices of the different sorts sold for the feeding of cattle, horses, etc.

Grade	Number of brands	Protein guaranties	Average protein guaranty	Approximate average selling price
High protein	23	20 to 26	24	$34 50
Medium protein	18	16 to 19	17⅛	29 00
Low protein	47	4.6 to 14	10½	32 00

There is obviously no relationship between protein content and selling price; and he who needs protein to balance his farm grown grains and roughages need not be deterred by price in choosing the high rather than the low grades.

Let us next compare the prices of the different sorts sold for the feeding of poultry.

Grade	Number of brands	Protein guaranties	Average protein guaranty	Approximate average selling price	1916 ± 1915
Meat meals	8	20 to 48	40	$57	—$1
Mashes	16	11 to 20	15	44	—$1
Scratch feeds	24	9 to 11	10	42	+ 0
Chick, etc., feeds.	13	10 to 24	14	44	— 3

Let us finally note the following statement of average guaranties and selling prices of concentrates which may prove of interest in this connection.

Grade	Number of brands	Protein guaranties	Average protein guaranty	Approximate average selling price	1916 ± 1915
High protein, 20-40%					
Cottonseed meal	28	38-41	39	$38	+$4
Linseed meal	12	30-38	34	42	+ 2
Gluten meal	1	40	40	38	0
Gluten feed	14	23-24	24	33	— 1
Distillers' dried grains...	14	26-31	29	35	— 1
Brewers' dried grains....	6	19-27	23	30	0
Medium protein, 15-20%					
Wheat bran	52	11-18	15	27	— 2
Wheat middlings	44	11-17	16	31	— 2
Wheat mixed feed.......	48	13-18	16	31	— 1
Low grade (red dog) flour	14	15-17	16	35	— 3
Low protein, 8-15%					
Hominy feed	12	9-10	10	32	+ 1
Alfalfa meal	11	12-14	13	31	— 4
Dried beet pulp	4	8	8	29	— 1

Cottonseed meal sells at higher prices than ever before and is of poorer grade than ever before. Linseed meal also has gone up in price. The other concentrates, as compared with the prices at which they were sold at corresponding dates the previous year, were a dollar or two cheaper. The proprietary feeds on the whole sold at the same or somewhat lower prices.

Notwithstanding these changes in price, which in general are downward, it is still true that it is often possible to buy standard concentrates and make home mixtures of a high protein content at a saving as compared with the purchase of ready mixed goods of the higher protein grade. This statement is based on calculations which involve the use of reasonable proportions of the ingredients claimed, sufficient in each case to meet the guaranty statement made by the manufacturers. However, as the feed prices now are quoted, taking into account the cost of mixing at home, the prices asked for these high protein rations are not exorbitant; neither, on the other hand, is there any monetary saving as a rule in their purchase as compared with buying their ingredients.

The high protein ready-rations seem to be thoroughly desirable combinations; with rare exceptions high class ingredients are used in their construction. The molasses and stock feeds are of a different sort. Among the list of ingredients declared by the manufacturers of the high protein foods one finds but rarely the acknowledgment of the use of a manufacturing by-product of relatively inferior feeding value. It is quite otherwise with the lower grades. Among the molasses and stock feed statements one finds such ingredients as "ground grain screenings," "clipped oat by-product," "ground and bolted grain screenings," "recleaned grain screenings," "oat clippings," "flax plant by-product," "cooked sphagnum," "grain screenings," "oat meal by-products (oat middlings, oat hulls, oat shorts)," "ground recleaned grain screenings," "oat hulls," "cob meal," "screenings," "ground corn and cob." Yet the prices asked for goods which proclaim the carriage of such material is but little less per ton than those asked for higher graded goods. Perhaps two to three dollars are saved. The fact that materials like "oat clippings," "cob meal," "ground grain screenings," etc., are not offered as such on Vermont markets and that their commercial values are not known to the writer, prevents the calculations upon which was based the above statements as to the relative money values of ready mixed and home mixed high protein rations.

STATEMENT CORRECTING ERROR IN BULLETIN 189

The Dewey Bros. Co. take exception to the statement made in bulletin 189 to the effect that their Corn 3D Dewey Grains was more than one percent below its protein guaranty, claiming that the guaranty as there set forth—namely 28 percent—was incorrectly stated, that it actually was 26 percent. They claim not to have received the station's advance notice of alleged shortage. They further say that they do not use tags, that the bags were indistinctly stencilled, and intimate that the sampling agent mistook poorly printed sixes for eights. They affirm most positively that never have they made a 28 percent guaranty on their goods.

The sample in question was taken by a careful sampling agent of long experience; yet it is conceivable that this suggested error occurred. It is obviously impossible to determine the facts by resampling, since a full year elapsed between sampling and protest. Hence the Station accepts the sellers' statement at face value and withdraws the remark to which exception is taken and the guaranty statement as printed upon which the remark was based.

IV. CONCERNING THE OAT CROP

BY J. L. HILLS

INTRODUCTION

For eight years the annual feeding stuff inspection bulletin has been made the vehicle for the purveyal of an informational article dealing with feeding practice, following in this respect in the wake of the fertilizer control bulletins in which informational articles concerning fertilizers were issued for the first time in 1902. This practice is warranted by the somewhat wide latitude which is accorded the Station by the feeding stuffs law which permits it to include in its feeding stuffs inspection bulletins "such additional information in relation to the character, composition, value and use of such feeding stuffs as circumstances may advise." The feeding stuffs bulletins which have been of this character in the past have discussed the following matters:

1908.	No. 138.	The viability of weed seeds in feeding stuffs.
1909.	No. 144.	Concerning the manufacture and nature of feed; the economics of feed purchase; the formulation of grain rations; statement concerning feeding.
1910.	No. 152.	Principles and practice of stock feeding, including discussion of animal nutrition, feeding standards and sundry economic considerations, as well as a full glossary and tables displaying the several feeding standards, the average composition of roughages and concentrates, digestion coefficients and digestible ingredients and a "convenience table" giving the pounds of dry matter and digestible ingredients.
1911.	No. 158.	Concerning feeding standards, being a review of the energy value scheme; the Minnesota station findings and the Scandinavian feed unit system; summer soiling suggestions.
1912.	No. 164.	Condimental feeds.
1913.	No. 171.	Concerning the Vermont hay crop.
1914.	No. 180.	Concerning feeding practice; including discussions of what the cow does with the feed she eats, how to balance a ration, advisable roughages to grow, advisable grain feeds to buy, suggestions as to profitable milk production, and balanced rations for hens.
1915.	No. 189.	Concerning the corn crop.

It seemed advisable, since the hay crop had been discussed in 1913 and the corn crop last year, to review this year the other main Vermont roughage, the oat crop; and the present article is the result. There is nothing whatever original about it. It represents simply a compilation. Many federal and state publications as well as several of the more recent books dealing with this crop were used in its construction, especially farmers' bulletins 420 and 424 by C. W. Warburton, and Carleton's admirable book entitled "The Small Grains." The writer does not assume that the article is a complete monograph or anything more than a somewhat fragmentary presentation of the subject, loose jointed and none too well built.

ORIGIN

Only a guess can be made concerning the original habitat of the oat. It is thought to be western Asian or eastern European. It seems to have been cultivated first in northern and central Europe, within the confines of the present Russian Empire, being used there in animal feeding. It appears to have been sown in America by the earliest colonists. Its use in the feeding of the human kind is of comparatively recent date.

NATURE AND CLASSIFICATION

The oat is a grass, as much so as is timothy. Its stems are hollow and many jointed, averaging about 3½ feet in height; its leaves are rather broader and more numerous than those of wheat; its heads are of the panicle sort, either open and spreading or one-sided and closed, or, to use less technical terms, they are either of the spreading or of the "horse mane" or "banner" types. The oat grain is borne on small branches in "spikelets," 25 to 100 in number, enclosed within the "chaff," each spikelet as a rule containing two grains consisting of hull and kernel, the latter comprising two-thirds to three-fourths of the weight of the grain.

The modern classification of oats as given by Carleton recognizes seven distinct sorts; namely

1. The common or spreading oats, within which is comprised the vast majority of all cultivated varieties; characterized by spreading panicles or "tops."

2. The Oriental or side oats, also known as "banner," "horse mane," or "mane" oats; commercially important; of relatively recent

origin; characterized by compacted panicles or "tops," turned to one side like a horse's mane.

3. The hulless or naked oats; grown in central and eastern Asiatic highlands; commercially unimportant; "freaks" as it were.

4. The red, Mediterranean or "rustproof" oats; grown somewhat in the southern sections of this country.

5. The hairy or sand oats; commercially unimportant; a weed.

6. Short oats; commercially unimportant; slightly grown in western Europe.

7. Abyssinian oats: a wild African form; of no commercial importance.

Oats are classified commercially as white, mixed (all colors), red, rustproof, white clipped (the sharp ends of the grain clipped off and the grain otherwise improved in appearance, thus making them grade higher and weigh more), mixed clipped, and purified (chemically treated).

EXTENT OF THE CROP

Ninety-nine percent of the commercial crop is produced in the northern portion of the north temperate zone, doing best in such cool, moist climates as obtain in northern Europe, Canada, the American Northwest, in northern New England and in the states bordering on the Great Lakes. It is grown to some extent in central Asia, South Africa and the Argentine. The world's crop under normal conditions approximates four billion bushels annually, about one-fourth of which is grown in the United States. Oats rank fifth in value and fourth in acreage among American crops, being outclassed by corn, cotton, hay and wheat. Half this crop is grown in the five states of Illinois, Iowa, Wisconsin, Minnesota and Nebraska and a quarter in another five, namely, Indiana, Ohio, New York, Michigan and Pennsylvania. Indeed, every fifth acre of Wisconsin's improved farm lands is sown to oats, every seventh such acre in Iowa, Illinois and Minnesota, every tenth in Nebraska, Indiana and Michigan and every twelfth in Ohio, New York and North Dakota.

VERMONT'S OAT CROP

The census taken in 1909—a relatively unfavorable season for oats—showed that 71,510 acres were sown to oats in Vermont, and that 2,141,357 bushels were grown, an average of 30 bushels to the acre.

This was two-thirds as much again in area and one-fourth as much again in yield as were sown or yielded in corn. Indeed, the area in oats was greater by one-tenth than the combined areas planted to corn, wheat, barley, buckwheat, rye, peas and dry beans. Nearly two-thirds of the entire acreage and yield were grown in the five Champlain valley counties. The average area planted during the years 1900 to 1909 inclusive was 81,456, the average production 2,929,547 bushels, the average acre yield 36 bushels, which was exceeded only by the yields in the Northwestern and mid-Rocky Mountain States (35.9-46.3 bushels) and in Maine (37.1 bushels). The crop represented 1.4 percent of Vermont's total area. In other words, during these ten years one acre in every 71 acres of Vermont's entire area, including forests and mountains, was planted to oats.

The 1916 edition of the book on "Vermont Farms" issued by the Vermont Bureau of Publicity, Essex Junction, Vermont, says, touching her status as an oat growing state, that

"During the forty-year period, 1870-1909 inclusive, Vermont's average yield of bushels of oats per acre was the largest of any state in the Union. Last year (1914) only four states surpassed Vermont in the yield of bushels of oats per acre, and all these states were in the irrigated region of the West. Vermont's average yield was 42.5 bushels, while that of the United States was 29.7 bushels.

"Vermont's average yield for the past two years was 40.7 bushels per acre while the average yield for the United States for the same period was 29.4 bushels per acre. Vermont's average yield for the period, 1870-1909, was 35.1 bushels per acre, while the average for the United States for the same period was 27.6 bushels per acre.

"The states producing the largest number of bushels of oats in recent years are Iowa, Illinois, Minnesota, North Dakota and Wisconsin. The average yield of oats per acre in these states during the past two years was as follows: Iowa, 33.7 bushels; Illinois, 26.5 bushels; Minnesota, 32.9 bushels; North Dakota, 26.8 bushels; Wisconsin, 31.7 bushels. Not one of these states equals Vermont's average.

"The average Vermont price to farmers December 1 for the two-year period 1913-1914, was 53.5 cents. The average price for the period throughout the United States was 41.5 cents. The average price per bushel during the last four years in the states producing the largest number of bushels of oats was as follows: Iowa, 37.5 cents; Illinois, 41 cents; Minnesota, 36 cents; Wisconsin, 40 cents. Vermont's price was far better than that paid by any of these states. For the forty-year period, 1870-1909, the average Vermont price was 43.5 cents per bushel, while the average price for the whole country was 32.3 cents per bushel.

"In 1914 Charles G. Cady of Middlebury raised 1901¼ bushels of oats on 32½ acres, or an average of 58½ bushels per acre. The average yield per acre for the United States in 1914 was 29.6 bushels per acre." (Which it may be remarked parenthetically is less than two-thirds of Germany's acre yields. However, a comparison of this kind is always superfluous nowadays, since the whole world knows the "efficiency" of the German farmers).

Most of the crop grown in this country is home used, being fed on the farms on which it is grown. Less than one-third of it is shipped away. Prior to its export from its home locality its grade is sometimes bettered by the removal of inert matter, weed seeds and light oats by the process known as "fanning," or the market price and weight are increased by "clipping," a process which removes a portion of the hull from the grain tip. Sometimes discolored grain is bleached with sulphur or other chemical agents, a process which improves appearance, does not lessen food values, but is likely to impair germination. However, inasmuch as the feeding value of weathered or heated oats usually is the worse on this account, a lot thus furbished by chemical processes is likely to be less serviceable than its appearance would indicate.

THE SEED

VARIETIES

Varieties differ in color, size, shape, period of growth and ability to yield. They may be white or black, grey, yellow or red; they may be large and spindling or short and plump; they may need three months or they may need four and one-half months in which to mature. Some are spring, and some fall oats; and some are indifferent in this respect. The habit of growth also varies since some are spreading and some compact, the so-called banner or horse mane oats. So-called "lodge resistant" varieties have been vaunted, the value of which is more or less problematical.

Hundreds of varietal names exist and, as is common with most crops, it often happens that the same variety is named diversely in different localities or by different seed houses. New sorts spring up annually while older varieties pass into the discard and are forgotten. However, the number of varieties really adapted to the conditions of a given section is relatively small. A medium to late type usually is grown in the North Atlantic States, one carrying a large, plump white kernel. American Banner, Canada Cluster, Clydesdale, Probesteir, Swedish Select, Welcome and White Tatar are said by Warburton to be most commonly offered in this section.

Carleton establishes nine oat-growing districts in this country. In his "northeastern oat district" he includes the North Atlantic States (exclusive of southern New Jersey), West Virginia, northern Ohio, Michigan, the maritime provinces of Canada, Quebec and eastern Ontario. He states that white, spreading varieties usually are grown, citing the following as now grown or adapted to growth in this section: Abundance, Banner, Big Four, Cluster, Clydesdale, Daubeney, Lincoln, Long White Tatar, Ligovo, O. A. C. No. 72, Old Island Black, Silvermine, Swedish Select, Siberian, Tatar King, Victory, Welcome. He states further that mid-season or late oats seem to do better than early vareties; that in the more northerly regions earliness is an important factor in escaping rust, dry weather and in promptness of maturity; that the climate generally is well adapted to the crop; and that stronger straw, early varieties for northern sections and rust prevention are vital needs. This is an interesting epitome and is worth careful attention, because of the special knowledge possessed by its creator.

Any variety which is suited to the local conditions should yield well if given a favorable opportunity and if the seed is graded carefully, is plump, free from weed seed and trash, and is treated to kill oat smut. No hard and fast rule can be laid down with safety as to varietal choice. Soil, climate, altitude, latitude, affect the outcome. However, speaking broadly, the larger grained, medium to late varieties usually succeed best in the North. The close panicled or horse mane oats are likely to be hardier as a rule than the open panicled varieties and in regions where the season is long are likely to yield better; but in the long run in these latitudes the spreading varieties are more certain.

Oats vary greatly in weight, for the well known reason that the proportion of kernel to hull is highly unlike because of varietal, seasonal and other causes. Thus we have light oats and heavy oats. On this account legal weights of a bushel of oats have been established in most states, varying from the light weights in the southern states, typified by Maryland, 26 pounds, to the heavy weights of the far Northwest, typified by Idaho's 36 pounds. A legal bushel of oats in Vermont weighs 32 pounds. Of course "clipped oats" are relatively heavy. It is well understood that in buying and selling oats the weight always is specified.

The proportion of kernel to hull being variable, no fixed relation exists between bushel weight and kernel proportion. Usually oats run about two-thirds kernel, though they may be as low as 55 and as high as 80 percent kernel with the average about midway between these extremes. The proportion of grain to straw is influenced also by varietal and seasonal conditions. It may be as low as 1 to 1.3 or as high as 1 to 4.

As between varieties bearing relatively short plump grains and those with longer and more slender kernels there seems little to choose. The Illinois station after five years' trials found that the latter yielded a larger proportion of kernel to hull, whereas the Ohio station as a result of a trial with large numbers of varieties, arrived at the opposite conclusion. It appears that the varieties producing the more slender grain as a rule take more time to mature and in a short season might not fill well, thus increasing the proportion of hull and lowering the weight of a measured bushel. On the other hand the varieties with short, plump grains, maturing as they generally do somewhat earlier and hence becoming well filled out, are likely to yield more kernel proportional to the hull. All this means, in brief, that the ratio of kernel to hull is affected by the character and length of the growing season. Most American varieties are of the shorter, plump kernel type, ripening relatively early and thus escaping the ill effects of the summer winds.

SELECTION

If one seeks through seed selection to better his crop he should understand in the first place that the seed must be cleaned thoroughly and the larger grains chosen. It is suggested often that new seed be bought at a distance, advice which may or may not be worth taking. Unknown or ill adapted varieties should be declined. If one seeks new seed, whether of the same or of a different variety, and if one is to go outside of the immediate vicinity, seed should be sought grown in a drier and a colder climate rather than that grown in one less dry and warmer, for the crop grown in dry and cool regions is more likely to withstand untoward conditions than that grown in a moist and warm country. Many of our best sorts are of European origin, doing well when grown under climatic conditions resembling those of their native land. Thus Swedish oats grow well in this latitude and varieties from South Russia in the midwestern states. Indeed, most Russian varieties used in this country are of relatively high grade and are among our most valuable grain assets.

Heavy or light oats. Seed oats should be looked to with care. The better grades are screened and fanned in order to separate the light oats, small oats, weed seeds and "trash." The former germinate poorly and yield a relatively light crop; the latter are an obvious detriment. In one series of trials carried on for many years, heavy, common and light seed yielded in the ratio of 100 : 97 : 89, and in another in the ratio of 100 : 97 : 92, and in yet another in the ratio of 100 : 87 : 75. The heavier seed produced heavier oats and the lighter seed lighter oats.

Field selection. While it is well always to select large and heavy seed at the fanning mill or when making direct purchase, field selection also is worth considering. The yields and the quality may be augmented by choosing the best heads or plants in the field, by thrashing them in a lot by themselves and by planting them apart from the main crop, thus developing a special strain. A yet further refinement of this method, one not often resorted to except in the conduct of breeding trials, is thus to handle individual plants. Zavitz at the Ontario Agricultural College during many seasons consistently selected and sowed heavy, plump grains in comparison with those of lighter weight and reaped a harvest one-third greater as a reward for his work. He states that a 15 percent increase over average yields easily is possible if care is exercised in seed selection, a statement amply confirmed by the results of similar work carried on in other localities.

A concrete example. An excellent illustration of this matter of seed selection is afforded in the concise account given by the cerealist of the Federal Department of Agriculture in his recent book on "The Small Grains," setting forth the facts as to the "Swedish Select oats." This variety "was introduced into the United States by the author in the spring of 1899. It was obtained, along with other cereals, while making an exploration of the cold and semi-arid regions of Russia and western Siberia in 1898-99 in search of cereals adapted to corresponding conditions in this country. This oat apparently originated at Svalof, Sweden, as a pedigree variety developed by selection many years ago, and was grown afterward in Finland and in Petrograd province, Russia. Under the severe weather conditions of these localities it became acclimatized for a cold and dry climate.

The Swedish Select is a large-kerneled white oat, with a spreading top or panicle. The distinguishing marks are a blunt, plump kernel, usually with dark, slightly twisted awns and a heavy weight bushel. It is a very prolific variety, which quality, together with the size and weight of the kernel, no doubt is the result of previous selection. The usual weight of a bushel is 34 to 36 pounds, while in Montana a weight of 44 to 46 pounds is not rare. Comparisons of yields with other varieties therefore should be made on the basis of bushels by weight instead of measured bushels. Swedish Select also grows to a considerable height and produces much straw, its chief fault being a tendency toward overproduction of straw when grown on rich or low land. The roots are large and vigorous, giving the plants hardiness in cold or dry seasons. In the northern United States between the Great Lakes and the Rocky Mountains, the average annual production of this variety is at least 50,000,000 bushels, and in 1910 it was estimated that the annual farm value of the oat crop in Wisconsin alone was increased over $2,000,000 by virtue of the presence of this variety."

Oat breeding. The methods used by plant breeders in their efforts to improve by selection are several. While few farmers would carry out these requirements of care, a brief account of their processes seems worth including at this point. There is, in the first place, the sorting of the strains from admixtures caused by threshing operations, or by the use of several varieties on the farm or otherwise, a process involving hand picking the seed or the separate plants. Then the foreign plants, e. g., wild oats, barley, etc., must be removed from the standing crop, "roguing" as it is called. Then the cleaning and grading of the grain must be done, either by means of an air blast, by means of gravity or through specific gravity separation. The old time winnowing process roughly grades the seed, but the more modern fanning mill with its sieves of different mesh accomplishes a more effectual grading. A vertical series of sieves ranging from coarse to fine, set each at an angle with its neighbor, through which the grain passes of its own weight, serves to make separates on the basis of the size and shape of the kernels. And, finally, if the grain is immersed in a liquid—usually salt water—of such a density that kernels of average weight barely will sink, all the lighter kernels, the chaff, trash and many weed seeds float and may be skimmed off. It has been suggested by Derr that the solution used in smut treatment may be used to good advantage, thus killing two birds with one stone.

The improvement of the species has been secured yet further through the process of so-called "mass selection," the choice of the best plant from a plat or field for mass sowing in a separate field; by individual or "pure line" selection, that is to say the choice of a single, superior mother plant, which, with its resultant seed, is kept safe from cross pollenation, a process which contemplates vast numbers of such selections, protections and propagations, and, finally, the rigid elimination of the unfit and the isolation, propagation, increase and distribution of those fittest to survive.

Of course some work has been done along hybridizing lines, although less attention has been paid to this means of varietal improvement than to introduction and selection. Thus the Swedish Select, Clydesdale, Kherson, and Sixty-Day oats were introduced from foreign countries and improved by rigorous selection; but we have as yet no oat hybrids which are now commercially important.

TREATMENT FOR SMUT

Since the best of oat seed may be smutted, and since both the price and the quality are impaired seriously if the grain is smutty, a formalin or copper sulphate treatment, or a hot water dosage should be given the seed. One never is safe. Smut may occur any year. The threshing machine may bring it to a farm which never before has been infested. The seed may be soaked in the solution or it may be sprinkled upon the grain. The solutions, either of which may be used, are made up as follows:

(a) 1 pound commercial formalin (formaldehyde) to 40 gallons water.

(b) 5 pounds copper sulphate to 50 gallons water (suspended in a bag over night in the 50 gallons of water in order to facilitate solution).

Soaking process. Two vats (half barrels) are so placed that one will drain into the other. The upper vat is filled half full of the fungicide, the grain poured in, and thoroughly stirred. It is removed in ten minutes, piled, allowed to drain, spread out and shoveled frequently to facilitate drying. If copper sulphate is used, a ten minute immersion should be considered to be the extreme time limit, lest injury ensue.

Sprinkling process. This is less laborious and quite as effective. Smaller amounts of the fungicide are used but the proportions of disinfectant and water are the same. If copper sulphate is employed, the grain is piled in a heap on a clean floor and wet with an ordinary sprinkling can, not drenched but evenly moistened; it is shoveled as quickly as possible into another heap and back again until every grain is well wet; and then it is spread out to dry. If formalin is employed, the moistened pile is left for two or three hours, covered with sacks and then spread out to dry. A gallon to a bushel will suffice.

The hot water dosage is cheap and effective but must be done with much care. The temperatures must be just right, neither higher nor lower than is prescribed; and the thermometer must be accurate. Since thermometers are notoriously unreliable and since a change in altitude affects the boiling point, and since Vermont is a state of varying altitudes and, finally, since formalin is effective and cheap and relatively safe to use, it hardly seems worth while to describe the hot water treatment.

THE SOIL

TYPE

The relatively heavy soil types usually are apt to grow better oat crops than do the lighter sorts, although the latter, if well started with available plant food and if underlain with a fairly retentive subsoil, sometimes prove satisfactory. A slightly rolling piece is advisable, since its drainage is likely to be the better on that account. Heavy, wet clay and low undrained soils in general are not adapted to the growing of oats, neither are the richer types, since the crop is likely to be overfed, to grow too rapidly, to be weak-stalked and to lodge, as well as to be especially subject to plant disease. Yet on the other hand it should be remembered that few if any cereal crops use more water than oats in making a pound of dry matter, and that on this account a naturally retentive soil, one well stocked with humus, is needed.

SEEDING

Relatively little attention usually is paid in this section to the preparation of soil for the oat crop. Any procedure which will furnish a loose surface soil underlain with a fairly firm subsoil is thought to serve the purpose. There are those, however, who believe that greater care in seedbed preparation is well worth while. When following corn the seed quite commonly is broadcasted without any preliminary soil preparation whatsoever, a practise which, as a rule, is not to be advised. The land rarely is plowed, but usually both disking and harrowing are necessary to prepare the moderately fine seed bed with loose soil surface which is adapted best to the purposes of this crop. Experimental trials seem to indicate that at least as large a crop follows thorough disking as follows plowing. Since the crop is sown early and since a spring-plowed soil rarely can be put into shape soon enough, a piece which ought to be plowed should be handled thus in the fall, and be disked and harrowed in the following spring.

Date. Oats should be sown early, as soon as the land can be worked, since excessive heat injures the crop. They are sown in late April or early May in the northern states. This cool climate, cool weather crop laughs at spring frosts. Sometimes oats are sown in the late fall in order that they may be ready to germinate in the early spring, a procedure which lessens spring work and secures early germination, if the dangers incident to winterkilling and to alternate freezing and thawing during the winter are avoided. This practise is hardly to be advised in New England.

Rate. The amount of seed used varies with the soil and seeding methods. Seed goes farther on good soils than on poor soils; on clean soils than on weedy ones. If the crop is drilled, less seed is needed than if it is broadcasted. If selected seed is used, less is needed than if ungraded seed is sown, for the larger seed grows larger plants. From 8 to 12 pecks commonly are sown. The rate of seeding, within limits, does not seem materially to affect the yield, since the plants on thinly seeded pieces tiller enough more than the thickly seeded plants to make up for the difference.

Method. Oats usually are sown broadcast and harrowed in. If evenly distributed—which is no small task—and covered about an inch deep, the job is well done. Less seed is used as a rule when it is drilled. A better germination and a larger crop are secured. The results of many experimental trials are indeterminate as between broadcasting and drilling.

Depth. Shallow seeding usually is to be preferred, one to two inches deep, the former on the heavier types, the latter on the lighter. On a well disked field seed can be put in well by a couple of harrowings, though it should be remembered that a broadcasted seed never can be covered with perfect evenness.

FERTILIZATION

The soil may be lacking in one or more of several particulars. For example, it may be deficient either in nitrogen, phosphoric acid, potash or lime, in any two or more of them; they may be abundant but unavailable; the soil may be acid, in a toxic condition or physically poorly adapted to crop growth. To a greater or less extent these soil ills may be remedied by adequate fertilization, by crop rotation and by cultivation.

Careful and repeated experimental trials have proved that almost as much plant food is used in the production of a crop of oats as in growing any other cereal. This statement runs counter to the commonly accepted notion that the poorest land on the farm is plenty good enough for the oat crop. It is true that the oat crop is an avid feeder, that it can forage to better advantage than many other plants, that it will endure hardship better than will most cereals; but that does not mean that it will not respond to kindly treatment or that a judicious application of a well chosen commercial fertilizer may not be likely to prove profitable. Indeed, it is a shallow feeder, rooting in the upper two feet. Yet the fact above alluded to, that on over-rich soils the stalks becoming soft and weak cause the crop to lodge and to become the prey of plant disease, makes it difficult in the application of fertilizer for the farmer to steer between the Scylla of a scanty yield and the Charybdis of a lodged crop. Fertilizers are best applied with a grain drill attachment and at the time of sowing.

The use of barnyard manure rarely is wise, unless the soil is very poor and especially lacking in humus. It is better applied to a previous crop, such as corn. If the oats follow the corn in the rotation they will benefit by manurial residues, a rank growth of straw and lodging will be less likely and a larger grain yield more likely to occur than when manure is applied directly. Green manuring is seldom resorted to in this land of the cow and need not be described here. It is rarely worth while at this particular point in the rotation.

It often happens that small applications of nitrogenous fertilizer may be made to good advantage, more particularly with a view of forcing early growth and carrying the crop through the so-called "pouting" season. Oats grow rapidly and early in the season, before the weather warms up much and before nitrification becomes active. Consequently a modicum of nitrate of soda often works well. This is particularly true if the crop is to be hayed, a custom which is becoming increasingly common; for, as is well known, nitrogen tends to promote foliaceous growth and to retard maturity. Barnyard manure may be used to good advantage if the crop is to be hayed.

Available phosphoric acid is more likely to be the controlling plant food factor in the growth of a good oat crop than are either nitrogen or potash, although of course there are many exceptions to this rule. As the French say "no general assertion is wholly true—not even this one." It is held generally that a liberal use of available phosphoric acid tends to strengthen the stalk, to improve the quality of the grain and to lessen the likelihood of lodging; although any crop, no matter how well or how strong of stalk, may go down before summer storms.

Potash, even in the years when it is abundant—which certainly is not 1916—may be used to better advantage elsewhere, especially if the soil is relatively heavy. The crop rarely will note its omission on the clay loams. On the lighter types, however, its use has proved at times to be profitable.

Liming is of little use, although if the soil is very acid it may be worth while. It usually has little effect, one way or another. However, if a clover or grass crop is to follow the oats, often it will be sufficiently benefited to warrant the application of lime.

On the heavier soil types it is advised to apply about 50 pounds of nitrate of soda and 150 pounds of acid phosphate, adding perhaps in normal years on the sandier soil types, 20 to 30 pounds of muriate of potash.

In this connection, the specific suggestions made for 1916 fertilization, in Circular 10, dated December, 1915, seem worth reprinting. These, it should be noted are designed full more for a hayed crop than for one which is to be thrashed.

"Oats, barley, seeding down to grass. It is, of course, a common procedure to sow grain following corn directly or with a year's interval, depending upon the residual plant food for the forcing of crop growth. If a fertilizer is used at all, nitrate of soda may be sown in small amounts, or a 300 to 500-pound application may be made in the spring of a ready mixed or home mixed goods carrying 4 to 5 percent nitrogen and 8 to 10 percent available phosphoric acid. The nitrogen should be used largely in the mineral form, and preferably as nitrate, for reasons hitherto cited, though cost considerations may make it impracticable to do this. If the seeding is done in the fall, or if winter rye is sown, no nitrate should be used. (In this connection see the discussion of seeding down fertilization for grass, oats, barley and clover on pages 186 to 189 of Vermont station bulletin 171; free for the asking)."

In this connection the following statement touching the guaranteed composition of 22 "oat" or "grain" fertilizers sold in Vermont is of interest, as indicating the extreme differences of opinion among fertilizer manufacturers as to proper formulation for this crop. The 1914 guaranties are used for the reason that the character of the 1915 and 1916 brands is of course abnormal on account of potash shortages.

	Nitrogen	Available phosphoric acid	Potash
Four consist simply of acid phosphate and muriate of potash	..	10	2
Five contain acid phosphate, muriate and a little organic matter	¾	7-8	4
One carries a little organic matter, acid phosphate and a very low potash content	¾	7	1
Two carry a little more nitrogen and potash than the last	1¼	7	2
One carries medium to low percentages throughout	1¾	8	3
Three carry medium to low nitrogen and phosphoric acid contents but a high potash percentage	1¾	8	10
Three contain high nitrogen and potash contents..	3¼	6-10	7-10
Two carry high nitrogen, low phosphoric acid and high-medium potash contents	5	4-5	6
One consists approximately of ½ nitrate of soda, ⅙ muriate of potash, with phosphatic organic matter, probably bone, making up the residue.	8½	4½	8

The brands first listed are the lowest grades sold in Vermont, and the one listed last is the highest grade sold; yet both are designed for and both labeled "oats"; and, paradoxical as the statement may sound, both may work well when advisedly used. The high grade goods applied as a topdressing used in moderation and for a crop that is to be hayed, may be just the thing to use; or it may do much damage if freely used on fairly rich ground. The low grade goods, sown on land where the previous crop was well manured, may serve a good purpose. However, all these various sorts of combinations cannot be equally well suited to the growth of the oat crop. The extremes can be defended; but some of the intermediates, particularly those carrying high potash contents, seem "neither fish, flesh nor good red herring."

When all is said and done, however, it should be remarked that the oat crop stands in less need of fertilization than do most crops. Prolonged field experimentation at the Ohio station indicated that as a rule when complete fertilizers were sown the increased crop barely paid the fertilizer bill, but that when acid phosphate was used on oats to be threshed a marked crop increase often ensued, more than enough to reimburse the outlay for this ordinarily low cost source of plant food. It is very doubtful, however, in view of the present high cost of acid phosphate—nearly twice what it has cost in previous years—whether or not this statement now holds good.

CULTIVATION

Rolling after seeding has taken place may be worth while on the looser soil types, since it serves to warm them, to hasten germination and to increase yields; but it works ill on the heavier soil types. It is often well to follow the roller with a light harrow, since this forms a soil mulch and thus tends to retard evaporation. Actual cultivation is not often practised in this section, although after the oats are up the harrow with teeth at a 45 degree angle is sometimes run over drilled oats, parallel to and not crosswise of the planting, in order to lessen moisture losses. Such a practice is not advised if the seed has been broadcasted. During very dry seasons a light weeder is sometimes used.

WEEDS

Weeds, of course, are very undesirable soil inhabitants. They occupy much room which the crop could fill to much better advantage, crowd it and reduce the yield; they retard the growth of the infant crop; they consume plant food and soil moisture which otherwise would be available to crop growth; they sometimes tend to increase the extent of insect and fungus infection; their seed is a nuisance in threshing, their tops reduce the value of the hay and the value of the product is impaired; and it costs money to handle them at harvest. Any means whereby the oat crop can be made as nearly as may be weed free is worth thinking about.

Now most of the weeds in the oats are sown by the farmer. He buys and pays for them. The analyses of six samples of seed oats as printed in bulletin 192 show that one lot has 135 weed seeds to a pound. If a bushel of this seed is sown to the acre, a rather light seeding, more than 4,000 weed seeds are sown per acre, about one every square yard; and this was not a very bad lot of seed as seed goes nowadays; and each seed germinating and maturing may increase a thousand fold. Furthermore, some weed seed may lie dormant for years before germinating.

The weeds most common in Vermont oat fields are the wild mustard or charlock, popularly known as kale, and common ragweed. Hand eradication is of course out of the question. Clean seed and crop rotation will tend to control them. Wild mustard (kale), which is especially troublesome, may be controlled by spraying with iron sulphate, using 75 to 100 pounds to a barrel (50 gallons) of water. It is best applied before the older weeds come in blossom, otherwise seed may ripen even after the leaves are killed. A cloudy, "muggy" day with rain not immediately imminent, is the best time to choose. Cereals and grasses are not materially hurt by this spray; clover and alfalfa may be injured; and kale is killed. A potato spraying machine should serve the purpose. Under normal conditions the cost for materials is about $1.25 an acre; under present abnormal ones, much more than this.

THE CROP

Oats are grown for various purposes; to be hayed, thrashed, as a cleanser of soils, as a nurse for other crops, as a soil cover, and as forage, either alone or in conjunction with other crops. It is grown in rotation or sometimes continuously. In fact oats are a versatile crop.

Rotation.—An oat crop commonly follows a hoed crop and precedes grass. If this order is reversed, weeds, rankness of growth and lodging are likely to cause trouble, although, speaking broadly, oats are not as apt to be unfavorably affected by ill advised rotational plans as are other cereals. A common New England rotation is corn, oats, and grass and clover sown with the oats; a rotation often used in Maine potato growing regions consists of potatoes, oats and clover in a three-year succession; and a common mid-western five-year rotation consists of corn, corn, oats, grass and clover seeded with the oats, grass and clover. (In this connection, see the discussion of the crop rotation in bulletin 190).

As a cleansing crop. Their habit of early growth and the dense shade they cast make oats an admirable cleansing crop. When weed control is an important issue, a heavy seeding is advised. The crop may be either hayed or thrashed, but in either event should be cut before the weeds mature. Following the harvest the land should be pastured or else the weeds should be mowed or plowed under, the plowing being supplemented by occasional harrowing in order to destroy further weed growth. If a piece thus treated is planted to corn, potatoes, or other hoed crop the next year, its weed population will be likely to be eliminated by the end of the second season.

As a nurse crop. Oats are often thus used as a nurse for grass and clover, but this practise has its drawbacks, for the reason that the oat foliage is dense and the draft it makes on soil moisture great. The nurse sometimes uses so much water that the nursling suffers for thirst; and when the leafy parasol is furled the young plants wither. Then again the proneness of oats to lodge militates against their use for this purpose, as they are apt to smother the nursling crop. Barley serves a better purpose. If oats are used, the small and earlier varieties are to be preferred, because their water usage is less and they are harvested before the extreme hot weather comes on. Furthermore, a relatively light seeding drilling in and not broadcasted is advised in the interests of the new stocking. And, finally, the crop should be cut with a high stubble in order to protect and support the young crop.

As a cover crop. Oats are sometimes used as an orchard cover. Their heavy drafts on soil moisture serve to check tree growth and to harden the young wood; and their dense foliage serves to shelter the soil against overheating and to afford winter protection as well. Sometimes peas or vetch are sown with the oats, a practise which is generally advisable because of the increased nitrogen accumulation thus induced.

With other crops. Oats are often sown with other crops, more particularly Canada peas, rape or barley. Peas and oats are frequently grown for pasturage, soiling or for hay and they are sometimes thrashed. A bushel of peas to one to one and a half bushels oats are sown, at the rate of two to three bushels per acre. Sometimes vetch is used in lieu of peas, two parts vetch to one of oats. The yields and quality of the forage are improved by these admixtures.

When rape is used as an adjunct crop, the seed is usually sown lightly and harrowed in, a pound or two to the acre, a few weeks after the oats have been put in. This delayed sowing ordinarily gives the oats such a start that they can be harvested without difficulty, following which, if a rather high stubble is left, the rape crop grows rapidly and makes excellent sheep or hog pasturage. Of course it may be so sown as to be cut with the oats or oats and peas as a soiling crop.

Excellent grain yields often follow a mixed barley-oats seeding, particularly if early varieties of oats are used which ripen with the barley. This practise is common in Ontario where the crop is usually home-fed. Early Daubeney oats and Manchuria barley or Siberian or Banner oats and Chevalier barley have worked well.

CROP PESTS

Smuts. There are two oat smuts, both of which are destructive. The common or loose smut occurs to a greater or less extent wherever oats are grown. It destroys the entire grain, replacing it with a mass of black powder made up of the spores of the parasite. Entire heads sometimes are thus affected. The infected plants are somewhat stunted and the panicles shortened and constricted. A somewhat less common form, the so-called closed or covered smut, injures the kernels only and the spores are enclosed within the chaff. Indeed the smut spores gain their access into the growing parts of the plant at the time when the seed is germinating and they finally develop in the head. When an untreated smutty seed is sown, a smutty crop is likely to ensue; for the conditions which favor seed germination promote fungus development. Both smuts are easily combatted by the use of formalin, as is set forth on pages 55 and 56. This disease is sometimes prevalent in eastern oat fields and is often found in the West. One year with another it is thought to cause a loss approximating 3 percent of the total crop, a loss which mounts far up among the millions.

Rusts. Rusts are characterized by the appearance of roughened, irregular areas on the foliage and by spore discharge. There are two or three forms. The black rust is the more destructive, but the crown rust the more common. These maladies, attacking as they do the stem and leaves, naturally weaken the plant, interfere with its assimilative powers and lessen its ability to construct a crop of full kernels. The damage they do the country over is probably greater than that wrought by the smuts, but unfortunately they cannot be successfully combatted, save by early seeding, the planting of early varieties, the avoidance of ill-drained, over-rich soils and of highly nitrogenous fertilizers. Fortunately for us they are not as great a factor in oat raising in this section as they are further west and south.

Insects. Oats are not seriously troubled by insects. Chinchbugs, green aphis and army worms occasionally molest it in other sections and rarely in New England, in which event the burning along fences and in fields of the rubbish in which they are likely to hibernate may prove helpful. However, it does not often pay to spend much time and effort in fighting these pests, so far as the oat crop is concerned.

Stored grain is often injured by grain weevils and moths. Indeed the damage done in the country as a whole is placed at $50,000,000 annually. Their greatest havoc is wrought in the South and in the large grain storage centers, in cereal and feed mills, warehouses, seed houses, grocery stores, etc. The ravages may be controlled by heating to a temperature of approximately 120° F.; or by fumigation with carbon bisulphid or hydrocyanic acid gas. The heating process is of recent development and seems to be an admirable method when possible to apply. The use of the gas is less desirable. Both hydrocyanic acid and carbon bisulphid are highly poisonous, and the latter is inflammable as well. Tight bins and well informed and careful operators are needed if one is to attempt to "gas" these pests.

HARVEST

Early varieties mature in from 90 to 100 days; late ones in from 115 to 130 days. Oats are cut just before or as the heads begin to turn yellow, in the hard dough stage, either with a grain binder, cradle or a mower (when lodged), raked and cocked. If cut earlier than this, the kernel is immature and light in weight; if allowed fully to mature before harvest, the crop shatters, the grain discolors and in other ways is subject to loss. However, on large areas harvest should begin a bit early lest too much be cut too late. The grain is commonly shocked in the field where it ripens prior to thrashing. If green or weedy or if it has been wet by rain or dew, it is well to allow it to dry out a bit before shocking. Both round and oblong shocks are used, the latter being preferable if the crop needs to dry out further.

Shocks should be well built so that they will not blow over or expose the grain to adverse weather conditions, thus injuring color and quality. They may be covered with cap sheaves, a bundle or two firmly placed on top protecting the heads.

Just how the grain will be handled and kept between the time of cutting and of stacking or threshing, will be determined by the good judgment of the farmer. It is rapidly becoming the custom in many sections to thresh directly from the field. This procedure saves time and labor and expense, and works well whenever weather conditions favor and the crop will thresh well. If storms intervene, of course the outcome is less satisfactory. A grain which is not fully dried out is likely to heat, unless frequently stirred. It is of course often difficult to get the thrashing crew at the psychological moment.

Stacking is not as common in this section as in the grain growing states, where delays in thrashing necessitate the protection of shocked grain against the weather. It is quite an art to make a good stack, full-middled, properly bulged and well-topped. It is sometimes mowed away after it has dried out in the shocks there to remain until it is thrashed.

Oats must be thoroughly dry when thrashed. A better job is done and a better product obtained, one which is less likely to heat and mold than if an ill dried crop is handled. It were well to make sure that the machine is clean before it begins work and that it is doing its work properly, making as nearly a complete separation as possible. The straw is stacked or run into the barn as is most convenient.

The grain should be stored in clean bins above the ground level in such a manner that mustiness and discoloration may not occur. Being dry, it should be kept so. Oats readily absorb water and become musty. Musty oats have less feeding value than bright oats and, indeed, may be dangerous. They should be so stored that they may be kept vermin-free and insect-free. The large storage warehouses, elevators, etc., are usually so constructed that their bins may be fumigated.

COST OF A CROP

What does it cost to grow a bushel of oats? Many items, of soil preparation, seed, yield, thrashing costs, sundry overhead charges, enter into the determination of the matter. Estimates based on careful experimental studies are: Illinois 36 cents, Minnesota 23 to 31 cents, Iowa 29 cents, Wisconsin 31 cents, Nebraska 30 cents, Ontario 22 cents. Farmers' estimates often are lower than these figures, but they are likely to be fallacious, for farmers rarely give due consideration to such items as interest and the like. The statement has been made following an exhaustive series of comparisons that from five to eleven cents profit was made on a bushel of oats, exclusive of the by-products; and that crops of 25 bushels or less per acre were usually grown at a loss. It is quite safe to say that the margin of profit in growing oats is narrow and that high acre yields only are likely to prove profitable. Farmers, especially in the grain growing districts, are prone to hold grain in the home storage as against better prices. Such as contemplate this procedure should see to it that their bins are built so as to be light, well above ground and that they are so protected with metal lining or otherwise as to be rat and mouse proof.

FEEDING

CHEMICAL COMPOSITION AND DIGESTIBLE NUTRIENTS

The following data drawn from bulletin 152 show the composition, digestible nutrient content and fertilizing value of the oat plant and of its more common separates.

	Composition						Digestible nutrients					Fertilizing constituents		
	Dry matter	Ash	Protein	Crude fiber	Nitrogen free extract	Ether extract	Dry matter	Protein	Crude fiber	Nitrogen free extract	Ether extract	Nitrogen	Phosphoric acid	Potash
Fodder	62.2	2.5	3.4	11.2	19.3	1.4	23.4	2.5	6.2	12.0	1.0	0.49	0.13	0.38
Oats and peas.	78.7	1.7	3.5	6.0	9.1	1.0	14.9	2.6	3.6	6.1	0.6	0.56	0.12	0.54
Hay	15.0	5.2	9.3	29.2	39.0	2.3	45.9	4.8	14.0	21.8	1.5	...	...	...
Hay	8.9	6.2	7.6	29.3	45.1	2.9	49.2	4.0	14.9	24.8	1.8	12.2	0.50	0.80
Oat and pea hay	11.5	6.6	14.8	24.9	38.9	3.3	54.0	10.8	14.4	23.7	1.9	2.37	0.54	2.25
Straw	9.2	5.1	4.0	37.0	42.4	2.3	43.6	1.2	20.0	18.7	0.8	0.62	0.20	1.24
Oats	11.0	3.0	11.8	9.5	59.7	5.0	62.3	9.2	1.9	45.4	4.2	2.06	0.82	0.62
Hulls	11.5	6.6	14.8	24.9	38.9	3.3	54.0	10.8	14.4	23.7	1.9	2.37	0.54	2.25
Kernels	7.9	2.0	14.7	1.0	67.3	7.1	...	..	..	...	..	...	...	...

The green forage compares favorably with green corn fodder but is not quite as good as are green barley or rye. The addition of peas of course improves the forage, whether it is fed as a soiling crop or made into hay. Oat hay is better as a roughage for dairy feeding than timothy but hardly as good as barley hay. Since, however, barley hay, because of its beards, often is not as readily eaten as is oat hay, this difference is perhaps more apparent then real. Oat straw is distinctly the best of the cereal straws and compares fairly well in feeding value with corn stover. Notwithstanding the fact that oats are about one-third hull and about two-thirds kernel, they are quite as proteinous as wheat, more so than corn and nearly as much so as barley. Their fat content also is larger than that of any other grain and they contain considerable mineral matter. It is easy to see why oats occupy a prominent place in the feeding of the young. This is preeminently true of the kernel which is one-seventh part protein, two-thirds parts carbohydrates together with 7 percent of fat. One has but to compare the heartiness of his rolled oats breakfast as compared with that of any other cereal, be it corn, rice, wheat or what not, to appreciate the fact that oats are a rich ration.

The digestibility of the plant and its separates of course is an important matter. The hulls are relatively indigestible, but on the other hand they serve the useful purpose of giving bulk to the grain ration and lightening what otherwise might prove an over concentrated ration, thus tending to facilitate the process of digestion. This fact, however, does not warrant the excessive use of extraneous hulls, as in some proprietary mixtures offered on our markets. The entire grain contains as much digestible protein as do barley or corn and practically as much as wheat and as much digestible fat as corn and more than that in barley and wheat. Its carbohydrate contents are somewhat less, for obviously no grain can exceed others in all respects. Oat straw outclasses all others in digestibility and in its digestible nutrient content; and oat hay is superior in this respect to timothy.

The oat plant and all its separates are fed to stock; and the oat kernel enters into human food to a large extent.

ROUGHAGES

As a soiling crop. Oats or oats and peas make a good soiling crop. We have grown 19 tons of green forage to the acre, containing more than five tons of dry matter, equivalent to six tons of hay. Analytically it compares favorably with the red and alsike clovers. Oats, of course, are somewhat less proteinous in their nature. Every good dairy farmer knows the feed value of green oats and of oats and peas; and "good wine needs no bush."

As pasture. Sheep or hogs are sometimes pastured on oats or on oats and peas, although this is rarely done in New England. It is said that in some sections success has been attained by turning sheep or hogs onto a piece where the peas and oat crop has ripened, that it is well liked, that rapid and economical meat production has been secured, and, finally, that the harvest of the crop and the manuring of the next crop has been done for nothing.

As hay. Oat hay and pea and oat hay are quite common factors nowadays in Vermont farming. If cut when the oats are in the "milk," or nearing the "dough" stage, or if a mixed hay before the pods ripen, the crop proves both palatable and nutritious. The mixed hay is relished especially by cows and sheep. It is cut and cured perhaps less easily than is grass hay; but the process is the same. As little handling as practicable is advisable. From 2 to 3 tons per acre should be secured.

The straw. Oat straw is commonly fed to horses, cattle and sheep as a maintenance ration. It nearly equals corn stover for this purpose. Stock can be "wintered over" very fairly if access is had to a straw stack and a little hay and grain are fed. Oat straw is less likely to waste than is corn stover, because of its better physical condition. The stock generally feed directly from the stacks, a wasteful practise since much is trampled under foot. It were better, if roughage rules high in price, to feed in the manger or rack; but if roughage is cheap, the saving will hardly repay the labor outlay.

Oat straw is also used as bedding. It is a good absorbent, adds both bulk and humus to the manure and carries a considerable nitrogen and potash content. Its 25 pounds of potash to the ton is worth thinking about in these days of dearth.

GRAIN

Oats have been regarded as a mainstay in horse feeding for many generations. Indeed, some feeders know of almost no other grain in this connection. Their high protein content serves a necessary purpose in muscle construction and maintenance and in the development of the young. And their high crude fiber content is also an advantage in horse feeding, for the digestive system of the horse is not of the best and the complete mastication which the oats must receive tends to increase their digestibility. This very property renders them ill adapted to the feeding of swine. Practically the entire crop not used in oatmeal manufacture is fed to horses. While it is probably true that no other grain ration keeps them in better condition, perhaps none in quite as good condition, nevertheless equally satisfactory results may be attained with work horses if corn in part replaces oats. Indeed, brewers' dried grains, barley, bran and dried beet pulp have been used to advantage; and at the Ohio station a mixed clover and timothy hay was fed with ear corn and found quite as effective as a normal oats rations, the horses being in no wise injuriously affected nor was their endurance lessened. Moderate quantities of linseed meal, gluten feed or cottonseed meal mixed with corn has been fed in lieu of oats at less cost and with entire success. Oats are fed horses whole and rarely need be ground except for colts or animals with poor teeth. Musty grain should be avoided as well as new oats which are apt to induce diarrhoeal disturbance.

Oats, though well adapted to the purpose, usually cost too much to feed to cattle. They may be fed whole, crushed or ground, or in the form of corn and oat feed. Many proprietary feeds, so-called "dairy feeds," carry considerable quantities of light oats, oat hulls, etc., as is set forth on the label borne on the bag (see pages 27 to 34 of this bulletin). Oats may be fed to advantage to calves, lambs and ewes. If one is fattening stock, corn and oats will serve quite as well or better. The grain fed to youngsters should be ground. Oats are often used in poultry feeding, especially in conjunction with corn. A large share of the proprietary poultry foods contain oats (see pages 35 to 40 of this bulletin); and, when sprouted in warm flats or greenhouses, are fed in the winter to hens as a digestive stimulant and as a means of furnishing green feed.

Oatmeal is a staple diet in northern Europe, throughout this country and elsewhere, especially in the form of "rolled oats," the product of passing the clean hulless kernels between heavy rollers. It is a cheap, palatable, digestible, serviceable cereal food; perhaps there is none better, if well and long cooked. Imperfectly cooked oatmeal is poorly digested because the gluten envelops considerable starch and protects it from the digestive fluids; whereas thorough cooking overcomes this mucilaginous tendency and frees the starch. Its high digestible protein and fat content, greater than that of any other cereal, accounts for its premier position in human dietaries.

BY-PRODUCTS

Several by-products of the oat kernel accumulate in the manufacture of oatmeal for human food. Some, such as oat shorts, oat bran, oat dust, are collected in such small quantities as to be commercially negligible; others, such as oat hulls, small oats, broken kernels, etc., have become important articles of commerce. The small oats and broken kernels have much food value and very properly are employed in the manufacture of feeding stuffs. The oat hulls, however, are relatively so lacking in digestible nutrients that their use in such a fashion as a rule is undesirable; or, stating the matter another way, they are commonly sold in the guise of proprietary goods at a price out of proportion to their food values.

REFERENCES

The following bulletins, published within the last 20 years by the Federal Department and by several Experiment Stations, deal with various phases of the growing of the oat crop. Most of them, if in print, can be had for the asking of the Department or the Station.

VARIETIES

Bowman, M. L., and Burnett, L. C. Oats: varieties, seed, smut, seedbed, seeding. Iowa Sta. Bul. 96 (1908).

Carleton, M. A. Ten years' experience with the Swedish Select oat. U. S. Dept. Agr., Bu. Plant Ind., Bul. 182 (1910).

Lyon, T. L. Kherson oats. Nebr. Sta. Bul. 82 (1904).

Montgomery, E. G. Oats: variety tests, rate of sowing, cultivation. Nebr. Sta. Bul. 113 (1910).

Warburton, C. W. Sixty-Day and Kherson oats. U. S. Dept. Agr., Farmers' Bul. 395 (1910).

————. Variety tests: (New England stations). Me. Sta. Rpts. 1888, 1889, Buls. 24 (1888), 188 (1911), 229 (1914), 236 (1915); Mass. Sta. Rpts. 1889, 1894, 1896, 1898; Buls. 11 (1891), 18 (1892); R. I. Sta. Rpt. 1892, Bul. 26 (1893).

SEED SELECTION

Surface, F. M., Barber, C. W., and Pearl, R. Studies in oat breeding: I. Variety tests 1910-1913. II. Selection within pure lines. Me. Sta. Buls. 229 (1914), 235 (1915).

Warburton, C. W. Improvement of the oat crop. U. S. Dept. Agr., Bu. Plant Ind., Circ. 30 (1909).

Warburton, C. W., Burnett, L. C., and Love, H. H. Tests of selections from hybrids and commercial varieties of oats. U. S. Dept. Agr., Bul. 99 (1914).

CULTURE

Burnett, L. C. Oat culture in Iowa. Iowa Sta. Bul. 128 (1912).

Hume, A. N., Center, O. D. and Hegnauer, L. Methods of seeding oats: Drilling and broadcasting. Ill. Sta. Bul. 136 (1909).

Love, H. H. Oats for New York. N. Y. (Cornell) Sta. Bul. 343 (1914).

Warburton, C. W. Oats: Growing the crop. U. S. Dept. Agr., Farmers' Bul. 424 (1910).

Williams, C. G. Ten years' experiments with oats. Ohio Sta. Bul. 138 (1903).

Williams, C. G. Recent experiments with oats. Ohio Sta. Circ. 88 (1909).

Woods, C. D. Field experiments with oats. Me. Sta. Bul. 236, pp. 41-47 (1915).

WEEDS, INSECTS AND FUNGUS DISEASES

Adams, G. E. Destruction of weeds by chemicals. R. I. Sta. Bul. 133 (1909).

Bolley, H. L. Weeds and methods of eradication: Weed control by means of chemical sprays. No. Dak. Sta. Bul. 80 (1908).

Cox, H. R. Weeds: How to control them. U. S. Dept. Agr., Farmers' Bul. 660 (1915).

Dean, G. A. Insects destructive to grass and grain products stored in bins and granaries. Kans. Sta. Circ. 47 (1915).

Freeman, E. M., and Stakman, E. C. The smuts of grain crops. Minn. Sta. Bul. 122 (1914).

Moore, R. A. Oat smut. Wis. Sta. Bul. 91 (1902).

Moore, R. A. Treatment of oat smut. Wis. Sta. Bul. 111 (1904).

Moore, R. A., and Stone, A. L. The eradication of farm weeds with iron sulphate. Wis. Sta. Bul. 179 (1909).

Olive, E. W. The killing of mustard and other noxious weeds in grain fields by the use of iron sulphate. So. Dak. Sta. Bul. 112 (1909).

Pammel, L. N., and King, C. M. Destruction of weeds. Iowa Sta. Bul. 105 (1909).

Selby, A. D. Spraying to kill weeds—some useful methods. Ohio Sta. Circ. 102 (1910).

Shamel, A. D. Treatment of oat smut. Ill. Sta. Bul. 64 (1901).

Stevens, F. L. Prevention of oat smut and wheat smut. No. Car. Sta. Bul. 212 (1910).

Stuart, W. Treatment of oat smut. Ind. Sta. Bul. 87 (1901).

Wilson, A. D. Destruction of weeds. Minn. Sta. Bul. 95 (1906).

Woods, C. D. Wild mustard destruction. Me. Bul. 224 (1914); 236 (1915).

FEEDING VALUE

Bartlett, J. M. Oats as grain and fodder. Me. Sta. Bul. 70, (1901).

Chamberlain, J. S. The feeding value of cereals. U. S. Dept. Agr., Bu. Chem., Bul. 120 (1909).

Lindsey, J. L. The value of oats for milk production. Mass. Sta. Rpt. 25, Pt. I., pp. 141-153 (1912).

Merrill, L. H., and Mansfield, E. R. Cereal breakfast foods. Me. Sta. Bul. 84 (1902).

Robinson, F. W. Breakfast foods. Mich. Sta. Bul. 211 (1904).

Weems, I. B., and Ellis, C. E. Breakfast foods. Iowa Sta. Bul. 74 (1904).

Woods, C. D., and Merrill, L. H. Cereal foods. Me. Sta. Bul. 118 (1905).

Wood, C. D., and Snyder, H. Cereal breakfast foods. U. S. Dept. Agr., Farmers' Bul. 249 (1906).

MISCELLANEOUS

Carroll, W. P. A simple method of detecting sulphured barley and oats. U. S. Dept. Agr., Bu. Plant Ind., Circ. 40 (1909).

Smith, C. D. The shrinkage of cereals and their products. Mich. Sta. Bul. 191, pp. 160-169 (1901).

Smith, LeR. M. The sulphur bleaching of commercial oats and barley. U. S. Dept. Agr., Bu. Plant Ind., Circ. 74 (1911).

Warburton, C. W. Oats: Distribution and uses. U. S. Dept. Agr., Farmers' Bul. 420 (1910).

Weston, N. A. The cost of production of corn and oats in Illinois in 1896. Ill. Sta. Bul. 50 (1898).

JUNE, 1916 BULLETIN 198

University of Vermont and State Agricultural College

Vermont Agricultural Experiment Station

BURLINGTON, VERMONT

COMMERCIAL FERTILIZERS

by J. L. HILLS, C. H. JONES and G. F. ANDERSON

CONCERNING TILLAGE

by R. T. BURDICK

1781

BURLINGTON
FREE PRESS PRINTING CO.,
1916

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☞ Address all communications concerning station matters not to individual officers but to the Experiment Station, Burlington, Vt. Address inquiries concerning farm practice to Extension Service, Burlington, Vt.

Director's and State Forester's offices, chemical, horticultural and dairy laboratories are in Morrill Hall at the head of Main street; botanical and bacteriological laboratories are at Williams Science Hall, University Place; veterinary laboratories are at 499 Main street.

University farm and buildings are on the Williston road, adjoining the University grounds on the east.

INTRODUCTORY STATEMENT

The completion of the manuscript of this bulletin was made possible through the courtesy of the Director of the Minnesota Experiment Station. Professor R. M. Washburn, its joint author, when he withdrew from the Vermont Station employ to enter that of the Minnesota Station, had not completed his digest of the experimental work. The Minnesota Station authorities generously allowed him leave of absence for a considerable time, in order that the manuscript might be completed. Had it not been for this cordial cooperation, it would have been difficult to have pursued the matter to a successful issue, and the Station gratefully acknowledges its obligation for this courtesy.

It should be remarked in this connection that other circumstances likewise have conspired greatly to delay the publication of this bulletin which is based on work done several years ago.

J. L. Hills, Director.

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I. SUMMARY

II. The state fertilizer law provides that manufacturers shall state on each package the amounts of plant food it contains and shall make good in fact their claims; and it provides further that the Station shall determine whether or not in each case claims are made good.

Prior to this year the Stations of the North Atlantic States have established and used trade values in calculating the so-called "valuations." This year, owing to abnormalities in the trade in crude chemicals caused by wartime conditions, no trade values could be determined.

III. Results of inspection. The Station has drawn from dealers' stocks and analyzed 168 licensed brands, the output of 18 companies, all this year's goods. All the licensed brands but five were sampled and analyzed.

1. Quantity of plant food. Eighty-two percent of the brands met their guaranties. A few brands were not as good as they were said to be. The outcome on the whole is a fairly satisfactory one.

2. Quality of plant food. The quality of the crude stock used seemed to be beyond reproach. The organic nitrogen offerings were in the main satisfactory. A few brands contained potash. One hundred and sixty-two of the 168 brands carried appreciable amounts of mineral as well as of organic forms of nitrogen.

IV. Selling prices. The average selling price was $33.88. No valuation statement can be made this year owing to the anomalous situation now obtaining in the fertilizer trade as set forth on page 10.

V. The analyses of the fertilizers sold in Vermont this year appear on pages 33 to 42, and 45 to 49.

VII. A special article dealing with the principles and practice of tillage appears on pages 50 to 83.

II. INTRODUCTION

The fertilizer law enacted in 1902 provides that the yearly bulletin of the Station dealing with commercial fertilizers not only shall furnish the results of the analyses of these goods, but also may afford "additional information in relation to [their] character, composition, value and use." It further directs that publication be made "as promptly as the progress of the analyses will allow and as frequently as time and means permit." The annual bulletin issued during the summer discloses the analyses of all the brands collected, shows their composition during the preceding two and the current years,[1] contains a general review of the state trade, makes statements as to the quantity and quality of the plant food sold in the various brands, considers the comparative value of the average goods of the current and preceding years, and outlines the relationship between selling prices and valuations.[2]

These general matters are reviewed annually. In addition thereto there is presented yearly a somewhat full discussion of some special topic having to do with fertilization, a "feature" as it were. This plan was inaugurated in 1902, has been continued for more than a dozen years, and presumably will be pursued for several years to come. Thus the recipient of the bulletins who preserves them will in time possess a more or less complete treatise on the general subject of fertilization.

So far as possible technicalities have been, are and will be avoided and plain every-day language is used. Yet many who read will find that careful attention will be needed. For the assistance of such, glossaries of definitions were supplied in bulletins 99, 130, 143 and 154. These glossaries will be added to from time to time in the future whenever necessary. Anyone failing to grasp the meaning of the terms used should get bulletins 99, 130, 143 or 154 (if in print) and make use of their glossaries. They are free for the asking. The annual fertilizer bulletin is always thoroughly indexed.

The following statement outlines the "features" of the preceding bulletins:

1902. Bulletin 93. *Formulas for home mixing.*—56 pages. (Out of print).

1903. Bulletin 99. *Vermont's usage of fertilizers. Concerning fertilizer buying. Deficient plant food.*—88 pages. (Out of print).

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[1] Omitted in 1915 and 1916 owing to the untoward conditions wrought by the European war, compelling manufacturers to reduce or omit their potash offerings.

[2] Omitted in 1916 since no trade values were established.

1904. Bulletin 108. *Classification of commercial fertilizers sold in Vermont. Farm manures.*—68 pages. (Out of print).

1905. Bulletin 116. *How, when and what to use.*—104 pages. (Out of print).

1906. Bulletin 123. *Concerning the purchase of plant food. The moisture relations of the soil.*—68 pages. (Out of print).

1907. Bulletin 130. *Soil biology in its relation to fertilization.*—144 pages. (Out of print).

1908. Bulletin 135. *A quarter of a century of fertilizer inspection. Soil deterioration and soil humus.*—128 pages. (Out of print).

1909. Bulletin 143. *The service of a fertilizer control. Soil physiography.*—144 pages.

1910. Bulletin 154. *Soil classifications and adaptations.*—112 pages.

1911. Bulletin 160. *Limes and liming.*—144 pages.

1912. Bulletin 165. *A survey of the peat and muck deposits of Vermont.*—104 pages.

1913. Bulletin 173. *The principles of land drainage.*—96 pages.

1914. Bulletin 182. *Irrigation.*—104 pages.

1915. Bulletin 190. *Crop rotation.*—80 pages.

These were written in 1902, 1903, 1904, 1905, 1906, 1907, 1908, 1909, 1910, 1911, 1912, 1913, 1914 and 1915; but in the main they are quite as applicable to the purchase and use of fertilizers in 1916 and in succeeding years as they were when first penned. The reader of this bulletin who does not own a 143, a 154, a 160, a 165, a 173, a 182, or a 190, and wants either or all of them, has but to ask to receive. Nos. 93, 99, 108, 116, 123, 130 and 135 are out of print.

Circular 7 on "Plant Food Combinations for Sundry Crops" contains a reprint of the more important formulas, etc., originally issued in bulletin 116.

Circular 10, issued last December "Concerning the Use of Commercial Fertilizers in 1916," deals with the changed situation wrought by war conditions. It is a 16-page pamphlet and can be had for the asking.

THE FERTILIZER LAW (CHAPTER 213 P. S.)

The term "commercial fertilizer" is defined to mean "compounds and manufactured substances containing * * * two or more of the ingredients" (nitrogen, potash, phosphoric acid) but not "the separate ingredients used to manufacture the same, or * * * bone meal, land plaster, lime or a substance the product of nature which is not compounded." (Sec. 4973 P. S.).

The law provides that "every lot * * * of commercial fertilizer * * * shall be accompanied by a * * * statement * * * certifying the number of net pounds, * * * the * * * brand, * * * the name and address of the manufacturer, * * * and a chemical analysis stating the minimum percentages of nitrogen, of potash soluble in water, and of available and total phosphoric acids." (Sec. 4976 P. S. as amended by No. 182 of the Acts of 1912).

It provides that the "manufacturer, importer, agent or seller" (the latter only in case the manufacturer fails to comply with the law) "* * * shall annually * * * pay * * * a license fee of twenty dollars," which will permit "the sale of one brand of commercial fertilizer which shall be the product of the licensee." It further provides that "if a manufacturer * * * desires to sell * * * more than one brand, he shall annually * * * pay a license fee of twenty dollars for each * * * brand * * * in excess of one." "The fee (s) * * * cover and authorize sales * * * for the calendar year." (Secs. 4977-4978 P. S. as amended by No. 169 of the Acts of 1910).

It provides that any person offering unguarantied, over-guarantied or unlicensed goods shall be subject to a fine (Sec. 4981 P. S.); forbids the use of "leather or its products, hair, wool-waste, garbage tankage or inert nitrogenous material" unless explicit notice thereof be made (Sec. 4980 P. S.); provides that license fees be sent to the State Treasurer, and for the reimbursement of the Experiment station for expenses incurred (Sec. 4982 P. S.); for sampling, analyses and publication (Secs. 4990 and 4991 P. S.); forbids interference (Sec. 4993 P. S.); and prescribes the procedure in case of violation (Sec. 4989 P. S.). The act does "not apply to persons manufacturing, importing or purchasing * * * fertilizers * * * for their own use and not for sale in this State." (Sec. 4992 P. S.).

The full text of the law will be furnished on application.

LIST OF LICENSES

The following eighteen companies (or individuals) have paid licenses as required by law on the brands shown in the statements on pages 25 to 31 and in the tables on pages 33 to 42, and in the list of unsampled brands on the bottom of the next page. The sale within state limits of these brands and of these brands only is legal. All local agents, as well as intending purchasers, are warned against the handling of other brands, unless bought for personal use and not for sale. They are likewise warned against the sale of mixed goods of companies other than those listed herewith, since they render themselves liable to pay the required license fee. "Parties manufacturing, importing or purchasing fertilizers for their own use and not for sale in this State" are not affected by the restrictions of the law.

American Agricultural Chemical Co., 2 Rector St., New York, N. Y.
Armour Fertilizer Works, 930-938 Equitable Building, Baltimore, Md.
Bowker Fertilizer Co., 43 Chatham St., Boston, Mass.
Burlington Rendering Co., North Ave., Burlington, Vt.
Coe-Mortimer Co., 51 Chambers St., New York, N. Y.
Essex Fertilizer Co., 39 North Market St., Boston, Mass.
International Agricultural Corporation, Buffalo Fertilizer Works, 812 Marine Bank Building, Buffalo, N. Y.
Listers' Agricultural Chemical Works, Lister Ave., Newark, N. J.
Lowell Fertilizer Co., 40 North Market St., Boston, Mass.
National Fertilizer Co., 92 State St., Boston, Mass.
New England Fertilizer Co., 40A North Market St., Boston, Mass.
Parmenter & Polsey Fertilizer Co., 41 North Market St., Boston, Mass.
Reading Bone Fertilizer Co., 32-34 North Sixth St., Reading, Penn.
Rogers and Hubbard Co., Middletown, Conn.
F. S. Royster Guano Co., 1604-1614 Munsey Building, Baltimore, Md.
J. W. Sanborn, Pittsfield, N. H.
Sanderson Fertilizer and Chemical Co., Box 172, New Haven, Conn.
Virginia-Carolina Chemical Co., 24 Broad St., New York, N. Y.

COLLECTION OF SAMPLES

The sampling agents of the Station visited 110 towns and villages in Vermont during the spring of 1916 and drew 525 samples from dealers' stocks, representing 168 distinct brands, the output of 18 companies or individuals licensed to sell in Vermont. A sample was secured of every brand which was licensed, except the following:

American Agricultural Chemical Co.'s Williams & Clark's Americus Ammoniated Bone Superphosphate, 1916.

National Fertilizer Co.'s Tobacco Special (Sulphate), 1916.

National Fertilizer Co.'s XXX Fish and Potash, 1916.

Listers' Agricultural Chemical Works, Celebrated Onion Fertilizer.

Listers' Agricultural Chemical Works, Valley Brand.

CONCERNING TRADE VALUES

It has been customary at this point each year to print the "schedule of trade values" agreed upon by the Experiment stations of New England, New York and New Jersey. These trade values were determined by carefully studying and averaging the prices at which fertilizer crude stock sold in our larger markets, such as New York and Boston, at retail for cash during the six months preceding March 1st. The wholesale prices were also carefully scanned. The system has worked well for a long series of years. Prices of standard goods have fluctuated more or less, but not so much as to prevent averages being struck which were within bounds of reason. Not so, however, in 1916. For example, nitrate of soda sold at approximately $45 a ton during the early months of the war; but it rapidly began to slant upwards, was quoted at $49 in August, 1915, at $65 in December and was recently bought delivered at Burlington in small quantities at $80. Sulphate of ammonia has increased from about $60 in 1914 to $80 at the present time. Everyone knows that beefsteak costs money nowadays and shortage of cattle means shortage of animal ammoniates. Cottonseed meal has sold of late at more than $40 a ton delivered in Vermont; yet it was quoted at southern shipping points last August at $23. Acid phosphate has shot up in price like an ascending rocket, costing twice what it did a year ago. And potash is almost as extinct as the dodo and sells at ten times what it once sold for. All this has been set forth in circular 10 issued in December, 1915.

It is quite evident that averages cannot be made with safety under such circumstances and that even if an attempt was made to establish trade values they would have no validity in view of the rapidly changing conditions now existing. Hence it was that, after careful consideration of the entire matter, it was unanimously voted at the annual spring meeting of the directors of the New England, New York and New Jersey stations to establish no trade values for 1916.

It is realized that some users of commercial fertilizers may miss the ready means of comparison heretofore afforded by the valuation system. If so, they must blame the Teutonic or the Allied governments—according to their predilections—and not the experiment stations.

III. RESULTS OF FERTILIZER INSPECTION

1. AS TO THE QUANTITY OF PLANT FOOD

(*a*) COMPARISON OF GUARANTIES AND ANALYSES

The quality of the fertilizers sold in Vermont in 1916 has been on the whole good. Guaranties have been fairly well maintained, remarkably so in view of the unprecedented situation with which the trade has been forced to cope during the year. The proportion of deficiencies is normal. Most of the shortages are minor ones; and yet there have been a considerable number of cases where guaranties have been shaved so very closely that the margin of safety has been eliminated. With plant food at altitudinous prices the temptation to crowd the minimum guaranty has been great. In four cases brands were short of guaranty in respect to two ingredients; and since two of these brands contained no potash, these goods were deficient in all respects.

No trade values having been established for this year, this ready means of reckoning shortages cannot be resorted to. All forms of plant food stand in a sense on a parity, one being as good as another. There are a few brands decidedly deficient as thus measured, lacking respectively approximately 1⅛, ¾, ⅞ and ¾ percents of their promised plant food contents, equivalent to shortages of 9, 7, 7 and 7 percents of the amounts guarantied. The identity of these brands can be readily determined by reference to the tables of analyses.

The general situation is a good one. Faulty fertilizers, as judged by the comparison of promise and performance, are not very common, and the trade seems to be in a healthy condition. Indeed, comparison with the results attained in other states is on the whole a favorable one, since the proportion of guaranty maintenance seems better in Vermont than that commonly found elsewhere. Commercial fertilizers are shipped into Vermont earlier than into most of the other northern states. Whether to this fact or to other causes may be attributed the relatively small proportion of failures to furnish the promised plant food which usually obtains here cannot be said; but certain it is that, as judged by several years' control work, the Vermont farmer rarely buys a fertilizer of lower grade than is promised him.

The plant food shortages in the 33 deficients of 1916 were distributed as follows: Nitrogen, 8; available phosphoric acid, 24; potash, 5. Only eight of the 429 guaranties made on 168 brands by 18 manufacturers, or one in 54, were not made good within 0.50 percent of a single ingredient; and only four were lacking to an extent materially greater than this; an excellent result.

The condensed results of 20 years' inspection of the Vermont trade, so far as they relate to the maintenance of guaranty, follow:

Year	Number of brands analyzed	Number of brands up to or above guaranty throughout	Number of brands deficient	Percent of total number up to or above guaranty	Percent of total number affording commercial equivalent of guaranty
1897	134	113	21	84	94
1898	126	113	13	90	100
1899	137	105	32	77	90
1900	132	114	18	86	96
1901	134	118	16	87	99
1902	136	123	13	90	100
1903	111	106	5	96	100
1904	118	94	24	80	97
1905	130	92	38	71	94
1906	130	110	20	85	98
1907	129	99	30	77	94
1908	130	92	38	71	95
1909	133	111	22	83	96
1910	152	138	14	91	100
1911	157	146	11	93	99
1912	182	156	26	86	98
1913	177	153	24	86	98
1914	185	153	32	83	97
1915	173	144	29	83	98
1916	168	137	31	82	..

Whenever guaranties were not made good the analytical work was repeated, and invariably recourse was had to other samples taken a second time from the original shipments, except in cases where the goods had been used prior to the attempt a second time to sample them. It should be remarked, however, that it was more difficult to do this in 1916 than usual, for shipments were belated owing to freight car embargoes and hence samples were drawn and analytical work begun several weeks later than usual. When results seemed open to question, other samples elsewhere drawn were analyzed. Unusually high figures were similarly checked. Careful comparisons with the analytical results of previous years were instituted with a view of minimizing error and standardizing results.

The following table shows the number of brands sold by the different companies licensed in Vermont, the number of guaranties (nitrogen, available phosphoric acid, potash) made by each, and the number of failures to make the same good within the tolerance figures long adopted at this Station, namely, 0.10 percent of nitrogen and 0.20 percent of available phosphoric acid or potash.

Name of company	Number of brands	Number of guaranties	Number of guaranties not made good	Number of brands deficient in total plant food
American Agricultural Chemical Co.	**10**	**26**	**2**	**0**
Bradley Fertilizer Co. branch	**10**	**30**	**0**	**0**
Cleveland Dryer Co. branch	**3**	**9**	**0**	**0**
Crocker Fert. and Chem. Co. branch	**4**	**12**	**1**	**0**
L. B. Darling Co. branch	**2**	**6**	**0**	**0**
Great Eastern Fertilizer Co. branch	**4**	**12**	**1**	**0**
Pacific Guano Co. branch	**3**	**9**	**0**	**0**
Quinnipiac Co. branch	**3**	**9**	**0**	**0**
Read Fertilizer Co. branch	**3**	**9**	**0**	**0**
Williams & Clark Fertilizer Co. branch	**5**	**15**	**1**	**1**
American Agricultural Chemical Co.—Total	**47**	**137**	**5**	**1**
Armour Fertilizer Works	**9**	**24**	**2**	**1**
Bowker Fertilizer Co.	**12**	**32**	**1**	**0**
Burlington Rendering Co.	**6**	**13**	**1**	**0**
Coe-Mortimer Co.	**8**	**21**	**1**	**0**
Essex Fertilizer Co.	**6**	**13**	**0**	**0**
International Agricultural Corporation, Buffalo Fertilizer Works	**8**	**19**	**3**	**0**
Listers' Agricultural Chemical Works	**13**	**33**	**6**	**2**
Lowell Fertilizer Co.	**8**	**16**	**2**	**2**
National Fertilizer Co.	**4**	**12**	**0**	**0**
New England Fertilizer Co.	**6**	**13**	**0**	**0**
Parmenter and Polsey Fertilizer Co.	**8**	**17**	**0**	**0**
Reading Bone Fertilizer Co.	**7**	**15**	**4**	**2**
Rogers and Hubbard Co.	**6**	**13**	**3**	**1**
F. S. Royster Guano Co.	**9**	**22**	**4**	**1**
J. W. Sanborn	**3**	**6**	**4**	**3**
Sanderson Fertilizer and Chemical Co.	**3**	**9**	**0**	**0**
Virginia-Carolina Chemical Co.	**5**	**14**	**1**	**0**
Total	**168**	**429**	**37**	**13**

Thirteen of the 18 companies contribute brands to the delinquent list. Four furnish a single brand each; two, 2; four, 3; two, 4; and one, 5 brands.

The range of composition and the closeness with which guaranties are met are displayed in the following table. The condition of affairs it discloses, a close hugging of the guaranties, has obtained for years, as appears in the second table, which shows the excess of the average analysis over the average guaranty for five years. The manufacturers naturally do not mean to place more plant food than is absolutely necessary in their goods, which carry on the average only about seven percent excess over the minimum guaranty. Maximum guaranties, of course, are quite meaningless.

MAINTENANCE OF GUARANTIES BY LICENSEES

	PERCENT GUARANTIED			PERCENT FOUND			Excess of average analysis over guaranty
	Lowest	Highest	Average	Lowest	Highest	Average	
Nitrogen	0.8	8.25	2.43	0.88	8.91	2.61	0.18
Total phosphoric acid	6.	16.	10.14	6.48	16.88	10.94	0.80
Available phosphoric acid	5.	13.	9.13	5.46	12.69	9.54	0.41
Potash	0.	2.	0.57	0.	2.43	0.55	—0.02
Selling price	$22.50	$60.00	$33.88				

FIVE YEARS' COMPARISON OF THE EXCESS OF ANALYSES OVER GUARANTIES

	1912	1913	1914	1915	1916	Av'ge for 5 years
Nitrogen	0.21	0.20	0.17	0.31	0.18	0.21
Total phosphoric acid	1.02	0.82	0.85	0.89	0.80	0.88
Available phosphoric acid	0.29	0.41	0.44	0.53	0.41	0.42
Potash	0.47	0.54	0.29	0.14	—0.02	0.28
Valuation	$1.20	$1.90	$1.35	$1.36	$0.00	

While the above statement shows that the goods compare well on the average with the claims made for them, the tables on pages 33 to 42, and 45 to 49, as well as the statements on page 11, betray the fact that within this average lie concealed several deficiencies. It is but scant satisfaction to the buyer of a brand in which the amount of plant food guarantied is not furnished to know that the "average" is good. It is for him to exercise care and avoid buying such goods. Yet it should be said that this year no seriously faulty fertilizers, so far as guaranty maintenance is concerned, were sold. Some years, however, very deficient goods have been offered.

(*b*) COMPARATIVE VALUES OF FERTILIZERS IN 1915 AND 1916

It has been customary at this point in the annual fertilizer bulletin to compare averages. Thus in 1914 at this point it was said that "of the 193 brands of commercial fertilizers which were sampled by the Station during 1913 and 1914, 169 have been selected for the purpose of instituting a comparison of the characters of the goods sold under these brand names in each of the two years. Only those brands have been chosen which have been sampled both years." No such comparison can be made this year. Manufacturers were forced in 1915 by the potash situation decidedly to modify many of their brands as to their guaranties and in 1916 yet further changes had to be made. Many of the manufacturers have used new brand names or old ones slightly modified to meet this unprecedented situation. Others have sold their goods with unchanged brand names, but changed guaranties. It should be distinctly understood that this latter procedure is no crime, since the law does not and cannot control as to names. A manufacturer may, if he wishes, sell one year a high grade product named, let us say, Smith's Mighty Melon Maker, and the next year, using precisely the same brand name, sell the lowest of the low grades. *Caveat emptor;* it is for the buyer to beware, to watch guaranties and to buy accordingly.

The following statement shows the 1916 practice of the Vermont licensees.

New brand names used:

Armour Fertilizer Works,
F. G. Royster Guano Co.,
Virginia-Carolina Chemical Company.

"1916" placed after and made a part of each brand name, in order to distinguish it as a this year's formula:

American Agricultural Chemical Company,
Bowker Fertilizer Company,
Coe-Mortimer Company,
Listers' Agricultural Chemical Works,
National Fertilizer Company,
Sanderson Fertilizer and Chemical Company.

Former brand names used on most or all of the goods which often are quite unlike those heretofore sold under the same brand names:

Burlington Rendering Company,
Essex Fertilizer Company,
International Agricultural Corporation, Buffalo Fertilizer Works,
Lowell Fertilizer Company,
New England Fertilizer Company,
Parmenter and Polsey Fertilizer Company,
Reading Bone Fertilizer Company,
Rogers and Hubbard Company,
J. W. Sanborn.

A few typical examples of sales of brands similarly named but diversely guaranteed are shown herewith:

VEGETABLE

'14	guaranty:	2.46%	nitrogen;	7%	available phosphoric acid;	10%	potash
'15	"	3.28%	"	8%	" " "	4%	"
'16	"	4.1%	"	10%	" " "	0	"

CORN, GRAIN AND GRASS

'14	guaranty:	3.28%	nitrogen;	6%	available phosphoric acid;	10%	potash
'15	"	3.28%	"	8%	" " "	4%	"
'16	"	3.28%	"	10%	" " "	1%	"

TOPDRESSING

'14	guaranty:	5.7%	nitrogen;	6%	available phosphoric acid;	5%	potash
'15	"	5.8%	"	6%	" " "	2%	"
'16	"	5.8%	"	6%	" " "	0	"

POTATO AND TOBACCO

'14	guaranty:	0.82%	nitrogen;	6%	available phosphoric acid;	7%	potash
'15	"	0.82%	"	6%	" " "	4%	"
'16	"	0.82%	"	12%	" " "	0	"

OATS AND TOPDRESSING

'14	guaranty:	8.5%	nitrogen;	4.5%	available phosphoric acid;	8%	potash
'15	"	8.5%	"	4.5%	" " "	4%	"
'16	"	6%	"	6%	" " "	0	"

POTATOES AND CORN

'14	guaranty:	3.3%	nitrogen;	7%	available phosphoric acid;	8%	potash
'15	"	3.3%	"	8%	" " "	4%	"
'16	"	3.3%	"	8%	" " "	0	"

Let it be said again, it is no crime thus to modify formulas; but the ethics of such a procedure is open to question. The writer is frank to say that he believes that brand names ought to be altered whenever formulas are materially modified, that it is at once the honest and the expedient thing to do. Shakespeare's query "What's in a name" has pertinence in this connection.

(*c*) COMPARATIVE VALUE OF FERTILIZERS FROM 1897 TO 1916

The next table shows the average composition of the fertilizers as analyzed during the last 20 years. Every brand tested each year is included in the comparison, each one being given equal value. It is well understood that this is not strictly a correct method of calculation, but it is the best which can be done in the absence of data showing the consumption of individual brands. Inasmuch as high grade goods in the past have sold slowly, and, unfortunately, low grade brands as a rule readily, the actual average as used is probably somewhat lower than that shown in the table. Yet the evidence in hand indicates a rapidly lessening usage of low grades and a larger usage of medium and high grades.

AVERAGE COMPOSITION OF FERTILIZERS SOLD IN VERMONT FROM 1897 TO 1916

Year	Number of brands	Nitrogen	PHOSPHORIC ACID					Potash	Average ton selling price	Valuation each year's trade values	Selling price exceeds valuation	Selling price exceeds valuation, (percent)	Value of plant food received for a dollar (cts.)
			Soluble	Reverted	Insoluble	Total	Available						
1897	134	2.12	5.34	3.68	2.23	11.25	9.02	3.43	$29.19	$19.47	$ 9.72	50	67
1898	126	2.21	5.51	3.32	2.08	10.91	8.83	3.81	29.04	17.86	11.18	63	61
1899	137	2.06	5.08	3.32	2.26	10.66	8.40	4.10	28.75	17.39	11.36	65	60
1900	132	2.08	5.29	3.26	2.58	11.13	8.55	3.80	28.73	18.08	10.65	59	63
1901	134	2.08	5.34	3.23	2.41	10.98	8.57	4.33	28.75	19.44	9.31	48	68
1902	136	2.22	5.56	3.06	2.39	11.01	8.62	4.21	28.23	20.18	8.05	40	71
1903	111	2.02	5.13	3.42	2.50	11.05	8.55	3.79	28.25	18.59	9.66	52	66
1904	118	1.98	5.20	3.19	2.38	10.77	8.39	3.95	29.00	18.47	10.53	57	64
1905	130	2.03	4.63	3.63	2.63	10.89	8.26	4.18	29.62	19.04	10.58	56	64
1906	130	2.09	4.70	3.65	2.63	10.98	8.35	4.37	29.52	19.38	10.14	52	66
1907	129	2.16	4.40	3.60	2.40	10.40	8.00	4.65	30.57	21.21	9.36	45	69
1908	130	2.05	4.64	3.50	2.29	10.43	8.14	4.58	31.24	20.75	10.49	51	66
1909	133	2.08	5.25	3.07	2.21	10.53	8.32	4.70	31.43	18.84	12.59	67	60
1910	152	2.12	5.50	2.86	1.53	9.89	8.36	4.99	31.45	20.57	10.88	53	65
1911	157	2.06	5.69	2.60	1.56	9.85	8.29	4.94	31.41	19.53	11.88	61	62
1912	182	2.19	4.99	2.92	1.75	9.66	7.91	5.55	32.03	20.09	11.94	59	63
1913	177	2.37	4.69	3.16	1.37	9.21	7.84	5.96	32.64	21.24	11.40	54	65
1914	185	2.32	4.68	3.19	1.51	9.38	7.87	5.77	32.53	20.35	12.18	60	63
1915	173	2.48	4.81	3.85	1.43	10.09	8.66	3.00	33.06	20.64	12.42	60	59
1916	168	2.61	5.12	4.42	1.40	10.94	9.54	0.55	33.88	....	....	..	..

It ought to be remarked at this point that neither this table, nor the discussion of the table, should be construed too literally, for the reasons cited as to the usage of the several brands. Some attempt was made a dozen or more years ago to estimate the relative usage of the different grades, but without much success. No data are available that are trustworthy, while if one appeals to the individual judgment of those who are in close touch with the trade the inevitable personal equation enters to a large extent. The result of such an inquiry therefore seems so largely a matter of guesswork as to be hardly worth recording. The writer's judgment would place the average goods as actually used during the years immediately preceding 1915 at approximately 2.1 percent nitrogen, 8.5 percent available phosphoric acid, and 3.7 to 4 percent potash; in 1915 at approximately 2.3 percent nitrogen, 8.7 percent available phosphoric acid, and 2.5 percent potash; and this year at approximately 2.5 percent nitrogen, 9.5 percent available phosphoric acid and either a 0.95 percent potash content or none whatever.

The average commercial fertilizer sold in Vermont in 1914 contains 0.25 percent more nitrogen, 0.50 percent less available phosphoric acid and a percent more potash than the average sold in the decade previous to 1912. The 1915 goods as compared with last year's were 0.2 percent higher in nitrogen, 0.8 percent higher in available phosphoric acid and 2.75 percent lower in potash; and the 1916 goods were increased 0.1 percent in nitrogen and 0.9 percent in available phosphoric acid over the 1915 goods, and contained but one-sixth as much potash. Indeed, as compared with the average goods sold in 1912 to 1914 they contained one-eighth more nitrogen and one-sixth more available phosphoric acid; but as an offset to these increments they contained nine-tenths less potash.

The increase in the average of the ten years, 1905-1914, as compared with those of previous years is due to the high grade of certain goods sold for the first time in 1905, and to the entry in each of several years since, and especially during 1912-1914, of a number of very high grade goods. There are 50 more brands sold in Vermont today than were offered five years ago. This change in average quality is doubtless more apparent than real, for the newcomers inevitably are not at the outset as widely sold as are the old-timers. A survey of the last table indicates that there has been on the whole an up-grading in the last 20 years in the character of the goods used by Vermont farmers. Indeed there seem to be four periods of 4, 6, 7 and 3 years respectively, wherein there are to be found somewhat wide variations in the plant food contents of the average goods, particularly in phosphoric acid and potash as is shown in the following table:

1895-98	**nitrogen 2.19,**	**available phosphoric acid 8.75,**	**potash 3.60**
1899-04	**nitrogen 2.07,**	**available phosphoric acid 8.51,**	**potash 4.06**
1905-11	**nitrogen 2.08,**	**available phosphoric acid 8.25,**	**potash 4.63**
1912-14	**nitrogen 2.29,**	**available phosphoric acid 7.87,**	**potash 5.76**
1915	**nitrogen 2.48,**	**available phosphoric acid 8.66,**	**potash 3.00**
1916	**nitrogen 2.61,**	**available phosphoric acid 9.54,**	**potash 0.55**

2. AS TO QUALITY OF PLANT FOOD

(*a*) SOURCES OF PLANT FOOD IN LICENSED FERTILIZERS

The table on page 14 as well as those on pages 33 to 42 show wide ranges in composition, amounts of nitrogen varying from 0.88 to 8.91 percent, of available phosphoric acid from 5.46 to 12.69 percent, and of potash from zero to 2.43 percent. These figures alone, however, do not tell the whole story or, indeed, much of the story as to the character of the ingredients used, a matter of quite as much importance as their amounts. A further scrutiny into the details of the sundry analyses throws some light on the sources whence the plant food purveyed in the various brands is derived.

NITROGEN

In all but 6 of the 168 brands, nitrogen as nitrate of soda or sulphate of ammonia was present in appreciable amounts. Doubtless the fact that mineral nitrogen is now cheaper and more plentiful than is organic nitrogen explains its freer usage. Time was, not long ago, when the ratio of mineral to organic nitrogen was much less than it is today in the goods sold in Vermont, and when a large share of the goods contained neither nitrate nor ammonia salts. The amounts found in this year's goods vary from 0.07 to 7.12 percent, averaging 1.32 percent or 51 percent of the total nitrogen present in the brands carrying this ingredient, a very different situation than formerly obtained. Under certain circumstances and for certain purposes mineral nitrogen, particularly in the nitrate form, is to be preferred agriculturally to organic nitrogen; under other circumstances it is not as much to be desired. It is more readily available but is more easily lost by leaching. One cannot help but shudder to think of the great losses which must have occurred during this June of torrential downpours. Speaking broadly, however, the presence of mineral nitrogen in commercial fertilizers is to be favored for most of the purposes for which such goods are used in Vermont. It is an open question, however, whether manufacturers are not going too far in this matter. Fifty to 60 percent of nitrogen in mineral forms in some seasons may be a somewhat larger proportion than can be used to good advantage. An over-supply may be present at the outset and, following heavy rains, an under-supply during late July and August; yet on the other hand it is but fair to admit that manufacturers are often at their wit's end in attempting to secure an adequate supply of organic nitrogen of good grade. The usage of commercial fertilizers in this country is increasing by leaps and bounds. In 1900, 2,200,000 tons were produced; in 1913, more than 6,800,000 tons; and the increased crop acreage of 1915 doubtless absorbed fully 7,500,000 tons. Yet in the face of this situation the supply of many forms of organic nitrogen is shrinking both relatively and actually. Just what will happen a decade hence, just what manufacturers and farmers will do for organic nitrogen, is not easy to predict.

All the brands which carry nitrogen contain more or less organic nitrogen, derived doubtless as a rule from standard animal and vegetable ammoniates, such as dried blood, meat meal, fish scrap, tankage, etc. Probably tankage is at present its main source in a large proportion of the brands.

AVAILABILITY OF ORGANIC NITROGEN

In the tables of analyses, pages 33 to 42, appear tabulated data setting forth the character of the organic nitrogen used in the various brands offered for sale, with a view of indicating its serviceability to crop growth. This Station for nearly 20 years has thus "kept tab" on the quality of the organic nitrogen which was used in the several brands offered for sale. Long before it seemed advisable to print its analytical results it formed an opinion in many cases of the character of the organic nitrogen used in the fertilizers sold to Vermont farmers. It did not hesitate by correspondence and by personal interview to question the character of the organic nitrogen used in certain brands, and in times past not infrequently found its queries to be justified by facts, either directly acknowledged or at least not gainsaid by the manufacturers. Its long experience with the alkaline permanganate method of determining organic nitrogen availability, the long series of analytical results accumulated in its files during the past 18 years, the work done by other stations in this section of the country using the same method, have served to give it confidence in the essential accuracy of its findings.

The nitrogen contents of a fertilizer are now stated in the analytical tables in the following terms: Nitrogen in nitrates; nitrogen in ammonia salts; water soluble organic nitrogen; insoluble organic nitrogen; total nitrogen.

1. *Nitrogen in nitrates.* The percentage of nitrogen derived from nitrate of soda, a soluble mineral form of nitrogen immediately available to plant growth.

2. *Nitrogen in ammonia salts.* The percentage of nitrogen derived from sulphate of ammonia, a high grade gas-house or coke-oven by-product[1]; a mineral form of nitrogen readily available to plant growth.

3. *Water soluble organic nitrogen.* The percentage of nitrogen derived from organic sources which is soluble in water.[1] The presumption is that most organic nitrogen soluble in water is likely on that account to be relatively available to plant growth.

4. *Insoluble organic nitrogen.* The percentage of such organic nitrogen as is not soluble in water.

The organic nitrogen in the 168 brands analyzed in 1916 and reported upon in this bulletin seems to be sufficiently good quality to warrant passing in all but four cases. These four samples were submitted not only to be the standard alkaline permanganate but also to the neutral permanganate treatment, in order beyond peradventure to fix the status of their organic nitrogen contents. The analytical results are appended:

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[1] The nitrogen derived from calcium cyanamid would appear either here or as "water soluble organic nitrogen," or both, according to circumstances.

		Nitrogen as ammonia	Water soluble organic nitrogen	Water insoluble organic nitrogen	Total nitrogen	Guaranteed	Activity of insoluble nitrogen	
							Method	
							Alkaline permanganate	Neutral permanganate
		%	%	%	%	%	%	%
H 4	Listers' Plant Food.....	0.14	0.35	0.60	1.09	0.82	47	62
J 6	Royster's Cuckoo	0.48	0.05	0.42	0.95	0.82	48	73
J 9	Royster's Drillwell	0.79	0.58	1.23	2.60	2.47	48	83
J 11	Royster's Logical Compound	0.41	0.50	0.77	1.68	1.65	45	75

It would appear that 56, 44, 47 and 46 percents respectively of the total nitrogen and 63, 89, 68 and 60 percents respectively of the organic nitrogen of these four brands were derived from organic materials of low activity. The results, secured by the use of both the alkaline and the neutral permanganate methods, clearly indicate this condition. Furthermore a considerable proportion of the organic constituents were separated from the inorganic portions of these several samples, carbon tetrachlorid being used for the purpose,[1] and the nitrogen contents and activities of these separates were determined. The results are set forth in the following table. It will be observed that they fully substantiate the original findings.

		Total nitrogen	Insoluble nitrogen	Activity of insoluble nitrogen by the alkaline permanganate method
		%	%	%
H 4	Lister's Plant Food	3.78	2.74	36
J 6	Royster's Cuckoo	4.70	3.12	33
J 9	Royster's Drillwell	5.90	3.79	46
J 11	Royster's Logical Compound	5.62	3.40	36

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[1] Journ. Ind. and Eng. Chem., Vol. 6, No. 7, p. 508 (1914).

PHOSPHORIC ACID

Some companies furnish more total phosphoric acid in available form than do others; some, more of the water soluble relative to the citrate soluble or reverted than do others. Water soluble phosphoric acid cannot be other than of the best grade and is to be preferred to that not thus soluble. Citrate soluble phosphoric acid, while often, and perhaps usually, quite as good agriculturally as that which is soluble in water, may be of distinctly lower grade (agriculturally) if certain classes of phosphatic crude stock, such, for example, as ignited alumina phosphate, are used. Low soluble and high reverted phosphoric acid contents do not of necessity mean that the available phosphoric acid is not as serviceable as when the conditions are reversed, but that the likelihood of this being true is lessened.

The proportions of the total phosphoric acid found in the various brands to be in available forms varied from 55 percent to 97 percent. The proportions of available phosphoric acid found to be in a water soluble form varied from 2 to 80 percent. Grouped according to their manufacture it was found that extremes for available in total were 68 and 92 percents, for water soluble in available 31 and 70 percents. In other words the average goods made by one firm carried 92 percent of the total phosphoric acid in available form, while those made by another firm furnished but 68 percent in that shape, the remainder ranging between. Similarly, on the average 70 percent of the available phosphoric acid furnished by one manufacturer was soluble in water, while only 31 percent was thus soluble in the average goods of another firm. The low availability seems to be due in certain cases to the use of considerable quantities of incompletely dissolved bone or of bone meal. Whether in other cases it is due to this cause, to imperfectly cut phosphate rock, to the age of the goods, to the use of agriculturally inferior forms of phosphoric acid, or to other causes does not always appear.

POTASH

This ingredient is sold in mixed goods in the form of muriate, sulphate, kainit, or, very rarely, nitrate. Practically sulphate of potash does not enter into the Vermont fertilizer trade nowadays. The asterisk (*) appears in connection with the potash figures in the column thus headed on pages 42 and that one only, sulphate of potash being found to be present; where this sign does not appear, the potash was derived from muriate or kainit, or else a sufficiency of chlorin was present in other combinations to mark the presence of sulphate and entirely to nullify its good effects, if any such there be.

IV. THE RELATION BETWEEN SELLING PRICE AND VALUATION

The relationship of the selling price to the valuation of fertilizers of different grades has been elaborated annually for 20 years; but for the reasons set forth on page 10 such a relationship cannot be established this year. However, some statements may be made as to the relative costs.

The brands may be classified as to selling price as follows:

	Number of brands	Percentage of total	Average selling price
Low priced, selling at $31 or below......	48	29	$28.42
Medium priced, selling from $31.50 to $34.50	66	39	33.00
High priced, selling for $35 or more.....	54	32	39.84

What have fertilizers cost during this year of stress and strain as compared with previous years, when conditions were normal?

The following table sets forth this situation:

	Average	Low priced	Medium priced	High priced
Selling price 1914	$32.53	$26.08	$30.64	$39.66
Selling price 1915	33.06	26.46	31.84	40.35
Selling price 1916	33.88	28.42	33.00	39.84
Increase or decrease 1915 over 1914	+0.53	+0.38	+1.20	+0.69
Increase or decrease 1916 over 1914	+1.35	+2.34	+2.36	+0.18

It appears:

1. That the average 1915 goods cost a half dollar and the average 1915 goods nearly $1.50 more than the average ante-bellum fertilizer.

2. That the lower grades cost but little more in 1915 than in 1914 but that their price was raised nearly $2.50 in 1916.

3. That the medium priced brands were increased in price about $1.25 in 1915 and almost as much more in 1916.

4. That the high priced fertilizers were increased about 75 cents in 1915 but hardly at all in 1916 as compared with 1914. However,

these goods suffered more—much more—than their weaker sisters in the debasement of their quality on account of potash shortage.

How was the potash distributed in the 1916 goods?

Low priced	48 brands	19 contained 1 percent	30 percent
Medium priced	66 brands	37 contained 1 percent	56 percent
High priced	54 brands	35 contained 1 percent	
		2 contained 2 percent	69 percent

A third of the lower grades, rather more than half the medium grades and two-thirds the higher grades carried potash.

The 1916 goods sold in Vermont were, so far as their potash contents are concerned, of three sorts. A little more than half of them contained one percent of potash; a little less than half no potash whatever; and two brands were guaranteed to carry two percent of this rare ingredient. It is a pertinent question to ask what manufacturers charged for one percent of potash? Exact comparisons are not possible, because fertilizers cost more at some points in Vermont than at others, owing to differences in freight rates; but, speaking broadly, it seems safe to say that about $2.75 was charged in the lower grades and $4.50 in the medium and higher grades, or from about 14 to 23 cents a pound. It is quite safe to say that this modicum of potash was not worth the price asked for it. Had there been several percent present conceivably, not probably, it might have been worth 14 cents to the farmer; but one percent is an almost negligible quantity.

ELEMENTS DETERMINING THE PRICE OF A COMMERCIAL FERTILIZER

Many elements enter into the determination of the cost of a commercial fertilizer as it is usually bought by the farmer from a local dealer in relatively small amounts and on time. They include:

1. *Assembling.* The original wholesale cost of the crude stocks or ingredients to the manufacturer, who secures nitrate of soda from Chili, potash salts from Germany, pyrites for the manufacture of sulphuric acid from many localities in this and other countries, phosphate rock from Florida, South Carolina or Tennessee, sulphate of ammonia from Europe or from various points in this country, organic ammoniates from all sorts and conditions of places, from near at hand and from the ends of the earth. This original cost must of course cover the cost of mining and manufacture, of freight to the factory and the overhead charges incident to manufacture, shipping and jobbing.

2. *Mixing.* The cost of mixing, including the manufacture of sulphuric acid, the expense of grinding phosphate rock, bones, etc.,

the commingling in the requisite proportions of the several ingredients, their storage until dry, their regrinding, bagging and loading.

3. *Mixing.* The overhead cost on the charges which are necessarily connected with the assembling and the mixing of the plant food, covering such items as interest on investment, insurance, taxes, depreciation of the manufacturing plant, certain office charges, etc.

4. *Transportation.* Freight from factory to railroad station.

5. *Selling.* The overhead costs and charges inevitably connected with the sale of mixed fertilizers, covering such items as commissions to agents and dealers, interest charges on long credits, bad debts, advertising, and, finally, profits.

V. OBSERVANCE OF THE FERTILIZER LAW

LIST OF LICENSED COMMERCIAL FERTILIZERS

The following companies have paid licenses on the 168 brands specified on this and the next few pages, being the entire number of licensed brands save the five listed on page 9, which were not found on sale by the station sampling agents. This list also shows the names and addresses of the parties from whose stocks the samples were drawn and the laboratory sample numbers referring to the analyses on pages 33 to 42.

American Agricultural Chemical Co., 2 Rector St., New York.

K 3 *AA Potato Grower, 1916;* W. F. Cunningham, St. Albans.

A 1 *Ammoniated Fertilizer A;* H. E. Currier, Concord.

A 2 *Ammoniated Fertilizer AA;* E. P. Hayes, Arlington.

A 3 *Ammoniated Fertilizer AAA;* W. H. Gray, Orleans.

A 4 *Ammoniated Fertilizer AAAA;* E. J. Davis, Chester.

K 2 *General Crop Grower, 1916;* A. V. Fisher, Middlebury.

A 5 *Grass and Lawn Topdressing, 1916;* Fairview Farm, North Bennington.

A 6 *High Grade Fertilizer, 1916;* L. J. Mills, Groton.

K 1 *Special Grass and Garden Mixture, 1916;* H. N. Gray, Cambridge.

A 7 *Topdresser, 1916;* H. D. Dunn, Brownsville.

(Bradley Fertilizer Co. Brands)

A 12 *Bradley's Circle Brand Bone and Potash, 1916;* A. W. Clark, Marshfield.

A 8 *Bradley's Complete Manure for Corn and Grain, 1916;* Hoyt & McAllister, Williamstown.

A 9 *Bradley's Complete Manure for Potatoes and Vegetables, 1916;* Jones & Berry, Montpelier.

A 10 *Bradley's Complete Manure for Topdressing Grass and Grain, 1916*; N. M. Nelson, Barre.

A 11 *Bradley's Corn Phosphate, 1916;* Valley Grain Co., Brattleboro.

A 13 *Bradley's Eclipse Phosphate, 1916;* A. A. Pinney, Passumpsic.

A 14 *Bradley's High Grade Potato and Root Special, 1916;* Valley Grain Co., Brattleboro.

A 16 *Bradley's Potato Fertilizer, 1916;* D. I. Grapes, St. Johnsbury Center.

A 15 *Bradley's Potato Manure, 1916;* H. W. Myers, Bennington.

B 1 *Bradley's XL Superphosphate of Lime, 1916;* H. W. Myers, Bennington.

(Cleveland Dryer Co. Brands)

B 4 *General Crop Fertilizer, 1916;* Barber Grain Store, Windsor.

B 3 *Potato Phosphate, 1916;* L. J. Mills, Groton.

B 2 *Superphosphate, 1916;* Fairview Farm, North Bennington.

(Crocker Fertilizer and Chemical Co. Brands)

G 11 *Ammoniated Corn Phosphate, 1916;* F. L. Fish, Randolph.

B 6 *New Rival Ammoniated Superphosphate, 1916;* A. Lawrence, Derby.

B 5 *Potato, Hop and Tobacco Fertilizer, 1916;* M. S. Hastings, Corinth.

G 12 *Special Potato Fertilizer, 1916;* F. L. Fish, Randolph.

(Darling Fertilizer Co. Brands)

B 7 *Farm Favorite, 1916;* G. C. Moulton, Corinth.

B 8 *General Fertilizer, 1916;* G. C. Moulton, Corinth.

(Great Eastern Fertilizer Co. Brands)

B 9 *General Fertilizer, 1916;* A. St. Francis, Derby Center.

B 10 *High Grade Potato Fertilizer, 1916;* E. C. Norton, Wallingford.

B 11 *Northern Corn Special, 1916;* H. E. Currier, Concord.

B 12 *Potato Manure, 1916;* H. D. Dunn, Brownsville.

(Pacific Guano Co. Brands)

B 14 *Nobsque Guano, 1916;* M. Joselyn, Newport.

L 6 *Potato Special, 1916;* E. C. Place, Huntington.

B 13 *Soluble Pacific Guano, 1916;* Frank Ward, West Burke.

(Quinnipiac Co. Brands)

B 15 *Corn Manure, 1916;* W. B. Foster, South Londonderry.
K 13 *Market Garden Manure, 1916;* Valley Grain Co., Brattleboro.
B 16 *Potato Phosphate, 1916;* Vermont Soldiers' Home, Bennington.

(Read Fertilizer Co. Brands)

J 4 *Farmers' Friend Superphosphate, 1916;* O. Phoenix, Swanton.
C 1 *High Grade Farmers' Friend Superphosphate, 1916;* L. J. Mills, Groton.
J 3 *Practical Fertilizer, 1916;* O. Phoenix, Swanton.

(Williams & Clark Fertilizer Co. Brands)

C 3 *Americus Corn Phosphate, 1916;* D. E. Bushnell, Bennington.
C 2 *Americus High Grade Special for Potatoes and Root Crops, 1916;* Valley Grain Co., Brattleboro.
C 4 *Americus Potato Manure, 1916;* Frank Ward, West Burke.
K 15 *Royal Bone Phosphate, 1916;* C. A. Chapman, Ferrisburg.
C 5 *Special Prolific Crop Producer;* Jones & Berry, Montpelier.

ARMOUR FERTILIZER WORKS, 930-938 Equitable Bldg., Baltimore, Md.

K 7 *Five-Eight-One;* M. A. Nelson, Montpelier.
C 9 *Four-Eight-One;* M. A. Nelson, Montpelier.
K 4 *Four-Eight-Zero;* Ralph Denio, Bristol.
K 5 *One and a half-Nine-Zero;* E. O. Mead, Hinesburg.
C 8 *Three-Eight-One;* A. J. Dewey, Bennington.
K 6 *Two and one-half-Eight-Two;* W. P. Abbott, Bellows Falls.
C 7 *Two-Eight-One;* Fred Potter, Pownal.
C 6 *Two-Eleven-Zero;* M. A. Nelson, Montpelier.
C 10 *Wheat, Corn, Oats Special;* M. A. Nelson, Montpelier.

BOWKER FERTILIZER CO., 43 Chatham St., Boston, Mass.

H 15 *All Round Fertilizer, 1916;* Burlington Flouring Co., Burlington.
C 11 *Brighton Phosphate;* A. Goyette, North Troy.
E 4 *Corn Phosphate, 1916;* Powell & Comings, Richford.
H 16 *Farm and Garden Phosphate, 1916;* N. N. Morse & Son, Randolph.
E 3 *Hill and Drill Phosphate, 1916;* —— Martin, Bradford.
C 12 *Potato Phosphate, 1916;* H. E. Currier, Concord.
C 13 *Stockbridge General Crop Manure, 1916;* E. S. Garfield, South Londonderry.

C 14 *Stockbridge Cereal Manure without Potash, 1916;* M. A. Nelson, Montpelier.
H 9 *Stockbridge Early Crop Manure, 1916;* V. Badger, Alburg.
C 15 *Superphosphate with Ammonia, 1%;* George Shorey & Son, Lyndonville.
C 16 *Superphosphate with Ammonia, 2%;* H. E. Currier, Concord.
E 2 *Sure Crop Phosphate, 1916;* L. F. Fortney, Plainfield.

BURLINGTON RENDERING CO., North Ave., Burlington, Vt.

D 1 *Animal Fertilizer;* F. A. Crane, Danville.
D 2 *Grain Fertilizer;* A. St. Francis, Derby Center.
G 10 *Grass Fertilizer;* L. L. Allen, Craftsbury.
D 3 *Potato Fertilizer,* T. E. Meade, Guilford.
D 4 *Special Fertilizer;* L. L. Allen, Craftsbury.
D 5 *Vegetable Fertilizer;* W. B. Fifield, Plainfield.

THE COE-MORTIMER CO., 51 Chambers St., New York, N. Y.

F 1 *Columbian Corn and Potato Fertilizer, 1916;* C. J. Maxham, Woodstock.
E 5 *Gold Brand Excelsior Guano, 1916;* R. C. Eastman, Bradford.
F 3 *High Grade Ammoniated Superphosphate, 1916;* F. Terrent, Highgate.
E 6 *New Englander Special, 1916;* Adams & Davis, Chester.
F 4 *Red Brand Excelsior Guano, 1916;* M. A. Nelson, Montpelier.
F 2 *Standard Potato Fertilizer, 1916;* C. J. Maxham, Woodstock.
J 15 *Universal Fertilizer, 1916;* W. S. Brown, Underhill.
F 5 *XXV Ammoniated Phosphate, 1916;* E. Farrar, West Rupert.

ESSEX FERTILIZER CO., 39 N. Market St., Boston, Mass.

E 7 *Grain, Grass and Potato Fertilizer;* W. S. Wright, Lyndon Center.
H 7 *Manure for Corn, Grain and Grass;* H. E. Shaw, Stowe.
E 8 *Market Garden and Potato Manure;* Frank Thayer, Brattleboro.
F 6 *Potato Grower;* Hawthorne & Boynton, Bristol.
H 8 *Special Potato, Grass and Lawn;* H. E. Shaw, Stowe.
E 9 *XXX Fish Fertilizer;* I. H. Carr, Hardwick.

INTERNATIONAL AGRICULTURAL CORPORATION,
BUFFALO FERTILIZER WORKS, 812 Marine Bank Bldg., Buffalo, N. Y.

D 6 *Buffalo Ammoniated Phosphate;* Henry Ward, Arlington.
F 8 *Buffalo Economy;* C. Goodrich, Richmond.

D 7 *Buffalo Farmers' Choice;* A. H. Winslow, Bennington.
D 8 *Buffalo General Favorite;* Edward Foss, Plainfield.
D 9 *Buffalo High Grade Manure;* Edward Foss, Plainfield.
F 7 *Buffalo New England Special;* Russell Young, Bristol.
D 10 *Buffalo Top Dresser;* Edward Foss, Plainfield.
D 11 *Buffalo Vegetable and Potato;* A. H. Winslow, Bennington.

LISTERS' AGRICULTURAL CHEMICAL WORKS, Lister Ave., Newark, N. J.

K 8 *Atlas Brand Fertilizer, 1916;* M. A. Nelson, Montpelier.
F 16 *Corn and Potato Fertilizer, 1916;* G. B. Brown, Brownsville.
K 9 *Crescent Ammoniated Superphosphate, 1916;* B. F. Whelden's Sons, Ludlow.
H 5 *Excelsior Guano, 1916;* Sargent, Osgood & Roundy, Randolph.
G 16 *High Grade Special for Spring Crops, 1916;* W. A. Fields, East Hardwick.
H 3 *High Grade Topdresser, 1916;* C. J. Greene, Waitsfield.
H 4 *Plant Food, 1916;* H. O. Holt, Richford.
G 15 *Potato Manure, 1916;* H. H. Fisk, Waitsfield.
G 13 *Revised Vermont Corn and Potato Fertilizer, 1916;* B. D. Piper, Greensboro.
K 16 *Special Potato Fertilizer, 1916;* Sargent, Osgood & Roundy, Randolph.
H 1 *Standard Grass Fertilizer, 1916;* C. S. Brush, Jeffersonville.
G 14 *Success Fertilizer, 1916;* H. O. Holt, Richford.
H 2 *Superior Ammoniated Superphosphate, 1916;* H. H. Fisk, Waitsfield.

LOWELL FERTILIZER CO., 44 N. Market St., Boston, Mass.

F 9 *Animal Brand for All Crops;* D. G. Sargent, St. Johnsbury Ctr.
F 10 *Bone Fertilizer for Corn, Grain, Grass and Vegetables;* J. Loomis, North Bennington.
F 11 *Corn and Vegetable Manure;* E. F. Cleveland, Moscow.
F 12 *Empress Brand for Corn, Potatoes and Grain;* J. Allen, South Hero.
F 13 *Potato Manure;* H. W. Myers, Bennington.
H 6 *Market Garden, Special Grass and Lawn;* E. F. Cleveland, Moscow.
F 14 *Potato Phosphate;* H. A. McClarens, Barnet.
F 15 *Sterling Phosphate;* A. B. Tucker, Waitsfield.

National Fertilizer Co., 92 State St., Boston, Mass.

E 10 *Eureka Potato Fertilizer, 1916;* J. F. Maley, East Putney.
J 16 *Potato Phosphate, 1916;* O. L. Cobb, Bridgewater.
E 11 *Special Complete Fertilizer, 1916;* Andrew Thorburn, Norwich.
E 12 *Universal Fertilizer, 1916;* Andrew Thorburn, Norwich.

New England Fertilizer Co., 42 N. Market St., Boston, Mass.

K 11 *Complete Manure for Potatoes and Vegetables;* S. L. Stevens, Northfield.
K 12 *Corn and Grain Fertilizer;* S. L. Stevens, Northfield.
K 10 *Corn Phosphate;* E. Carlton, Barre.
H 12 *Potato Fertilizer;* B. W. Earle, Chester.
H 10 *Potato and Vegetable;* W. A. Sinclair, Johnson.
H 11 *Superphosphate for All Crops;* E. P. Osgood, Newfane.

Parmenter & Polsey Fertilizer Co., 40 N. Market St., Boston, Mass.

D 12 *Corn and Grain Fertilizer;* Henry Osgood, Danville.
L 5 *Grain Grower;* E. Taylor, Orleans.
D 13 *Plymouth Rock Brand Fertilizer for All Crops;* A. W. Newton, Wallingford.
L 3 *Potato and Vegetable;* Edson Holden, South Barre.
D 14 *Potato Fertilizer;* E. Taylor, Orleans.
L 1 *Potato Phosphate;* W. H. Vaughn, Middlesex.
L 4 *Special Potato;* Edson Holden, South Barre.
L 2 *Star Brand Superphosphate;* G. Gates, Essex Center.

Reading Bone Fertilizer Co., 32-34 North 6th St., Reading, Pa.

E 13 *All Crop Special;* T. J. Hayes, Arlington.
E 16 *Farmers' Tankage and Potash for Corn, Grain and Grass;* A. Sears, Richford.
H 14 *Never Fail Crop Grower;* I. Goodnow, St. Albans.
H 13 *Prize Winner;* S. Strong, Waitsfield.
E 14 *Special Grain and Grass Producer;* Ivan DeRosie, Woodstock.
E 15 *Potato and Tobacco Manure;* W. W. Bryant, Troy.
L 7 *Truck, Fruit, Tree, Vine, Potato and Tobacco Grower;* W. A. Soule, Alburg.

Rogers & Hubbard Co., Middletown, Conn.

G 1 *All Soils—All Crops Phosphate;* E. S. Tewksbury, Randolph.
G 2 *Complete Phosphate;* A. W. Allen, Barre.
G 3 *Fertilizer for Oats and Topdressing;* A. W. Allen, Barre.

G 4 *Potato Phosphate;* W. W. Goodnow, Brandon.

G 5 *Soluble Corn and General Crops Manure;* J. T. Barker, Hinesburg.

J 5 *Soluble Potato Manure;* J. H. Hathaway, Brandon.

F. S. ROYSTER GUANO CO., 1255 Calvert Bldg., Baltimore, Md.

J 6 *Cuckoo Crop Grower;* P. Mullen, Richford.

J 7 *Curfew Ammoniated Superphosphate;* Don Camp, South Barre.

J 8 *Defender Fertilizer;* O. Howard, South Barre.

J 9 *Drillwell Phosphate;* Don Camp, South Barre.

J 14 *Goodwill Ammoniated Superphosphate;* A. J. Clark, Sutton.

J 10 *Log Cabin Guano;* Don Camp, South Barre.

J 13 *Innovation Ammoniated Superphosphate;* W. H. Hill, Colchester.

J 11 *Logical Compound;* Morrow Bros., Swanton.

J 12 *Penguin Ammoniated Superphosphate;* H. C. Royce, Sheldon Springs.

J. W. SANBORN, Pittsfield, N. H.

L 8 *Prof. Sanborn's Chemical Fertilizer for Grass and Grain;* Ward Lumber Co., Moretown.

J 2 *Prof. Sanborn's Chemical Fertilizer for Use in Hill and Drill;* H. C. Farnsworth, Milton.

J 1 *Prof. Sanborn's Chemical Fertilizer for Potatoes and Corn;* H. C. Farnsworth, Milton.

SANDERSON FERTILIZER AND CHEMICAL CO., Box 172, New Haven, Conn.

G 6 *Atlantic Coast Bone, Fish and Potash, 1916;* Ralph Wood, Essex Center.

G 7 *Corn Superphosphate, 1916;* W. A. Renfrew, Wells River.

G 8 *Potato Manure, 1916;* Martin Lee, Castleton.

VIRGINIA-CAROLINA CHEMICAL CO., 24 Broad St., New York, N. Y.

D 15 *Ammoniated Bone Phosphate for all Crops;* A. W. Clark, Marshfield.

G 9 *High Grade Corn and Vegetable Compound;* Arthur Brown, Jericho.

D 16 *Owl Brand Potato Fertilizer;* A. W. Clark, Marshfield.

E 1 *Plow Brand Fertilizer;* A. W. Clark, Marshfield.

K 14 *Twentieth Century Potato Manure with 2 Percent Potash;* M. A. Nelson, Montpelier.

CONCERNING THE TABLES ON PAGES 33 TO 42

These tables, from the point of view of the execution of the law, form the essential part of the bulletin. Therein are displayed side by side what the fertilizer manufacturer says he will furnish and what he does furnish, the one in *italics,* the other in **black face.** Furthermore all the details are given in order that the buyer may judge not only how much or how little plant food he gets for his money but how good or how inferior it is and what parts are good and what less good. While it is doubtless true that most buyers pay no attention to the work of the control, many who have done so have profited thereby in getting a larger return in plant food for a dollar spent as a result of their study of the matter. And in order that such as may wish to grasp the full purport of these tables may be enabled to do so, there has been published from time to time brief explanatory matter, and several years ago, a series of very full, almost painfully full, explanations of the meaning and significance of each piece of data was printed in bulletin 143.

In brief it may be said that the parallel **black face** and *italic* columns are the most serviceable means of comparing promises and actualities so far as the quantity of plant food is concerned; and that the other figures help one to determine more particularly the quality of a given fertilizer.

In this connection attention is called to the explanatory matter on pages 43 and 44 concerning the new and simplified form of tables dealing with the results of fertilizer inspection, as well as to the tables themselves on pages 45 to 49.

ANALYSES OF LICENSED FERTILIZERS

	BRAND	NITROGEN						PHOSPHORIC ACID							POTASH	
		In nitrates	In ammonia salts	Water soluble organic	Insoluble organic	Total found	Total guaranteed	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Found	Guaranteed
	American Agricultural Chemical Co.															
K 3	AA Potato Grower, 1916	1.16	0.98	0.39	1.05	**3.58**	*3.70*	2.50	5.07	1.83	**9.40**	*9.*	**7.57**	*8.*	**1.59**	*1.*
K 1	Special Grass and Garden Mixture, 1916	2.80	4.00	0.99	1.12	**8.91**	*8.25*	3.16	2.30	1.02	**6.48**	*6.*	**5.46**	*5.*	**1.04**	*1.*
A 1	Ammoniated Fertilizer A	0.46	0.07	0.18	0.27	**0.98**	*0.82*	4.14	6.28	1.93	**12.35**	*11.*	**10.42**	*10.*	...	..
A 2	Ammoniated Fertilizer AA	0.75	0.58	0.07	0.32	**1.72**	*1.65*	5.60	5.16	1.21	**11.97**	*11.*	**10.76**	*10.*	...	..
A 3	Ammoniated Fertilizer AAA	1.05	0.77	0.20	0.65	**2.67**	*2.47*	5.42	4.58	1.84	**11.84**	*11.*	**10.00**	*10.*	...	..
A 4	Ammoniated Fertilizer AAAA	1.44	1.05	0.26	0.86	**3.61**	*3.29*	5.76	4.24	1.10	**11.10**	*11.*	**10.00**	*10.*	...	..
K 2	General Crop Grower, 1916	0.61	0.48	0.28	0.49	**1.86**	*1.65*	3.92	5.54	2.02	**11.48**	*10.*	**9.46**	*9.*	**0.97**	*1.*
A 5	Grass and Lawn Topdressing, 1916	1.57	1.27	0.33	0.90	**4.07**	*3.7*	2.96	5.24	1.36	**9.56**	*9.*	**8.20**	*8.*	**0.91**	*1.*
A 6	High Grade Fertilizer, 1916	1.05	0.77	0.29	0.63	**2.74**	*2.47*	4.62	4.40	1.32	**10.34**	*10.*	**9.02**	*9.*	**0.99**	*1.*
A 7	Topdresser, 1916	1.53	1.42	0.45	0.91	**4.31**	*4.1*	4.70	3.64	1.30	**9.64**	*9.*	**8.34**	*8.*	**0.88**	*1.*
	(Bradley Fertilizer Co. Brands)															
A 12	Circle Brand Bone and Potash, 1916	0.82	0.41	0.25	0.41	**1.89**	*1.65*	5.28	4.52	0.76	**10.56**	*10.*	**9.80**	*9.*	**1.00**	*1.*
A 8	Complete Manure for Corn & Grain, 1916	1.46	1.21	0.20	0.74	**3.61**	*3.29*	5.16	4.15	1.05	**10.36**	*10.*	**9.31**	*9.*	**0.92**	*1.*
A 9	Complete Manure for Pot. & Veg., 1916	1.37	1.12	0.17	0.88	**3.54**	*3.29*	4.20	4.97	1.15	**10.32**	*10.*	**9.17**	*9.*	**1.08**	*1.*
A 10	Complete Man. for Topdr. Grass & Grain	1.61	1.48	0.19	1.07	**4.35**	*4.1*	4.64	4.34	0.82	**9.80**	*9.*	**8.98**	*8.*	**1.00**	*1.*
A 11	Corn Phosphate, 1916	0.77	0.60	0.06	0.39	**1.82**	*1.65*	5.86	4.90	1.00	**11.76**	*11.*	**10.76**	*10.*	**0.96**	*1.*
A 13	Eclipse Phosphate, 1916	0.51	0.30	0.19	0.44	**1.44**	*1.23*	5.96	4.45	0.95	**11.36**	*11.*	**10.41**	*10.*	**1.00**	*1.*
A 14	High Grade Potato & Root Special, 1916	0.61	0.51	0.15	0.34	**1.61**	*1.65*	6.04	4.74	0.82	**11.60**	*11.*	**10.78**	*10-*	**1.16**	*1.*
A 16	Potato Fertilizer, 1916	0.94	0.53	0.25	0.56	**2.28**	*2.06*	3.96	4.58	0.78	**9.32**	*9.*	**8.54**	*8.*	**1.01**	*1.*
A 15	Potato Manure, 1916	0.98	0.74	0.21	0.67	**2.60**	*2.47*	4.68	4.72	1.34	**10.74**	*10.*	**9.40**	*9.*	**1.01**	*1.*
B 1	XL Superphosphate of Lime, 1916	0.98	0.70	0.42	0.60	**2.70**	*2.47*	4.08	5.55	0.97	**10.60**	*10.*	**9.63**	*9.*	**1.04**	*1.*

ANALYSES OF LICENSED FERTILIZERS

	BRAND	NITROGEN						PHOSPHORIC ACID							POTASH	
		In nitrates	In ammonia salts	Water soluble organic	Insoluble organic	Total found	Total guaranteed	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Found	Guaranteed
	American Agricultural Chemical Co.															
	(Cleveland Dryer Co. Brands)															
B 4	General Crop Fertilizer, 1916	0.42	0.32	0.17	0.21	**1.12**	*0.82*	4.08	4.39	0.67	**9.14**	*9.*	**8.47**	*8.*	**0.84**	*1.*
B 3	Potato Phosphate, 1916	0.98	0.56	0.30	0.51	**2.35**	*2.06*	4.62	4.12	0.80	**9.54**	*9.*	**8.74**	*8.*	**0.95**	*1.*
B 2	Superphosphate, 1916	0.84	0.49	0.21	0.49	**2.08**	*1.65*	4.42	5.96	1.34	**11.72**	*11.*	**10.38**	*10.*	**0.89**	*1.*
	(Crocker Fertilizer & Chemical Co. Brands)															
G 11	Ammoniated Corn Phosphate, 1916	0.72	0.65	0.31	0.56	**2.24**	*2.06*	4.00	4.64	1.02	**9.66**	*9.*	**8.64**	*8.*	**1.12**	*1.*
B 6	New Rival Ammoniated Superphos., 1916	0.43	0.34	0.21	0.14	**1.12**	*0.82*	5.30	5.64	1.00	**11.94**	*11.*	**10.94**	*10.*	**0.94**	*1.*
B 5	Potato, Hop & Tobacco Fertilizer, 1916	1.02	0.63	0.28	0.53	**2.46**	*2.06*	4.40	5.77	0.89	**11.06**	*11.*	**10.17**	*10.*	**1.09**	*1.*
G 12	Special Potato Fertilizer, 1916	1.34	1.05	0.27	0.88	**3.54**	*3.29*	3.72	5.96	1.16	**10.84**	*11.*	**9.68**	*10.*	**1.01**	*1.*
	(Darling Fertilizer Co. Brands)															
B 7	Farm Favorite, 1916	0.60	0.56	0.31	0.46	**1.93**	*1.65*	5.44	5.08	0.86	**11.38**	*11.*	**10.52**	*10.*	**0.93**	*1.*
B 8	General Fertilizer, 1916	0.35	0.32	0.17	0.25	**1.09**	*0.82*	3.90	4.90	0.92	**9.72**	*9.*	**8.80**	*8.*	**0.83**	*1.*
	(Great Eastern Fertilizer Co. Brands)															
B 9	General Fertilizer, 1916	0.35	0.35	0.28	0.28	**1.26**	*0.82*	4.68	4.47	0.93	**10.08**	*9.*	**9.15**	*8.*	**0.88**	*1.*
B 10	High Grade, Potato Fertilizer, 1916	1.14	0.93	0.54	0.86	**3.47**	*3.29*	4.68	4.74	1.02	**10.44**	*10.*	**9.42**	*9.*	**0.88**	*1.*
B 11	Northern Corn Special, 1916	0.73	0.67	0.46	0.46	**2.32**	*2.06*	3.84	4.92	1.14	**9.90**	*9.*	**8.76**	*8.*	**0.76**	*1.*
B 12	Potato Manure, 1916	0.74	0.63	0.43	0.55	**2.35**	*2.06*	5.58	4.42	1.33	**11.33**	*11.*	**10.00**	*10.*	**1.04**	*1.*

ANALYSES OF LICENSED FERTILIZERS

	Brand	Nitrogen						Phosphoric Acid							Potash	
		In nitrates	In ammonia salts	Water soluble organic	Insoluble organic	Total found	Total guaranteed	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Found	Guaranteed
	American Agricultural Chemical Co.															
	(Pacific Guano Co. Brands)															
B 14	Nobsque Guano, 1916	0.31	0.25	0.24	0.25	**1.05**	*0.82*	4.44	4.01	1.07	**9.52**	*9.*	**8.45**	*8.*	**0.92**	*1.*
L 6	Potato Special, 1916	0.75	0.62	0.46	0.56	**2.39**	*2.06*	2.80	6.10	1.06	**9.96**	*9.*	**8.90**	*8.*	**0.86**	*1.*
B 13	Soluble Pacific Guano, 1916	0.70	0.56	0.31	0.39	**1.96**	*1.65*	5.82	4.56	1.28	**11.66**	*11.*	**10.38**	*10.*	**1.01**	*1.*
	(Quinnipiac Co. Brands)															
B 15	Corn Manure, 1916	0.63	0.56	0.28	0.39	**1.86**	*1.65*	4.68	5.88	1.44	**12.00**	*11.*	**10.56**	*10.*	**0.96**	*1.*
K 13	Market Garden Manure, 1916	0.97	1.42	0.49	0.84	**3.72**	*3.29*	4.76	4.82	0.82	**10.40**	*10.*	**9.58**	*9.*	**1.05**	*1.*
B 16	Potato Phosphate, 1916	0.70	0.63	0.44	0.58	**2.35**	*2.06*	4.62	3.84	1.16	**9.62**	*9.*	**8.46**	*8.*	**0.94**	*1.*
	(Read Fertilizer Co. Brands)															
J 4	Farmers' Friend Superphosphate, 1916..	0.77	0.60	0.42	0.60	**2.39**	*2.06*	4.16	4.20	1.06	**9.42**	*9.*	**8.36**	*8.*	**1.22**	*1.*
C 1	High Grade Farmers' Friend Super., 1916	1.35	1.18	0.31	0.67	**3.51**	*3.29*	4.84	4.98	1.22	**11.04**	*10.*	**9.82**	*9.*	**0.87**	*1.*
J 3	Practical Fertilizer, 1916	0.33	0.20	0.13	0.39	**1.05**	*0.82*	4.70	4.13	0.81	**9.64**	*9.*	**8.83**	*8.*	**0.83**	*1.*
	(Williams & Clark Fertilizer Co. Brands)															
C 3	Americus Corn Phosphate, 1916..........	0.65	0.44	0.13	0.46	**1.68**	*1.65*	4.44	6.42	0.58	**11.44**	*11.*	**10.86**	*10.*	**1.02**	*1.*
C 2	Americus H. G. Sp. for Pot. & Root Crops	1.33	1.02	0.26	0.76	**3.37**	*3.29*	4.68	4.82	0.72	**10.22**	*10.*	**9.50**	*9.*	**0.96**	*1.*
C 4	Americus Potato Manure, 1916	0.84	0.56	0.26	0.48	**2.14**	*2.06*	4.80	3.21	1.11	**9.12**	*9.*	**8.01**	*8.*	**0.91**	*1.*
K 15	Royal Bone Phosphate, 1916	0.52	0.46	0.53	0.35	**1.86**	*1.23*	7.22	3.21	1.59	**12.02**	*11.*	**10.43**	*10.*	**0.92**	*1.*
C 5	Special Prolific Crop Producer	0.35	0.28	0.17	0.32	**1.12**	*0.82*	4.88	3.29	0.94	**9.11**	*10.*	**8.17**	*9.*	**1.01**	*1.*

ANALYSES OF LICENSED FERTILIZERS

	BRAND	NITROGEN						PHOSPHORIC ACID							POTASH	
		In nitrates	In ammonia salts	Water soluble organic	Insoluble organic	Total found	Total guaranteed	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Found	Guaranteed
	Armour Fertilizer Works															
K 7	Five, Eight, One	...	0.86	0.33	3.16	**4.35**	*4.1*	5.36	2.33	1.41	**9.10**	*8.5*	**7.69**	*8.*	**0.98**	*1.*
C 9	Four, Eight, One	...	1.30	0.03	1.97	**3.30**	*3.29*	4.08	4.47	0.69	**9.24**	*8.5*	**8.55**	*8.*	**0.98**	*1.*
K 4	Four, Eight, Zero	...	1.09	0.49	1.65	**3.23**	*3.29*	6.26	2.05	0.57	**8.88**	*8.5*	**8.31**	*8.*	...	..
K 5	One and one-half, Nine, Zero	...	0.37	0.44	0.56	**1.37**	*1.23*	4.94	3.65	0.79	**9.38**	*9.5*	**8.59**	*9.*	...	..
C 8	Three, Eight, One	...	1.02	0.35	1.09	**2.46**	*2.47*	4.14	3.67	0.77	**8.58**	*8.5*	**7.81**	*8.*	**0.92**	*1.*
K 6	Two and one-half, Eight, Two	0.17	0.60	0.25	1.19	**2.21**	*2.05*	5.56	2.72	1.12	**9.40**	*8.5*	**8.28**	*8.*	**2.02**	*2.*
C 7	Two, Eight, One	...	0.20	0.23	1.18	**1.61**	*1.65*	3.52	3.82	0.82	**8.16**	*8.5*	**7.34**	*8.*	**0.98**	*1.*
C 6	Two, Eleven, Zero	...	0.46	0.17	1.02	**1.65**	*1.65*	7.80	3.84	0.78	**12.42**	*11.5*	**11.64**	*11.*	...	..
C 10	Wheat, Corn, Oats Special	...	0.23	0.05	0.67	**0.95**	*0.82*	5.14	1.97	0.59	**7.70**	*7.5*	**7.11**	*7.*	**0.95**	*1.*
	Bowker Fertilizer Co.															
H 15	All Round Fertilizer, 1916	0.56	0.46	0.27	0.46	**1.75**	*2.06*	5.28	6.45	1.27	**13.00**	*11.*	**11.73**	*11.*	**0.82**	*1.*
C 11	Brighton Phosphate	0.37	0.30	0.15	0.23	**1.05**	*0.82*	3.88	4.58	0.94	**9.40**	*9.*	**8.46**	*8.*	...	..
E 4	Corn Phosphate, 1916	0.37	0.86	0.29	0.55	**2.07**	*1.65*	4.68	5.88	1.14	**11.70**	*11.*	**10.56**	*10.*	**0.94**	*1.*
H 16	Farm and Garden Phosphate, 1916	0.59	0.46	0.25	0.56	**1.86**	*1.65*	5.04	5.91	1.05	**12.00**	*11.*	**10.95**	*11.*	**0.81**	*1.*
E 3	Hill and Drill Phosphate, 1916	0.78	0.90	0.23	0.76	**2.67**	*2.47*	4.00	5.38	1.22	**10.60**	*10.*	**9.38**	*9.*	**0.92**	*1.*
C 12	Potato Phosphate, 1916	0.65	0.51	0.17	0.39	**1.72**	*1.65*	5.12	4.98	1.18	**11.28**	*11.*	**10.10**	*10.*	**0.99**	*1.*
C 13	Stockbridge General Crop Manure, 1916	1.21	1.11	0.33	0.86	**3.51**	*3.29*	4.58	4.74	1.28	**10.60**	*10.*	**9.32**	*9.*	**0.90**	*1.*
C 14	Stockbridge Cer. Man. without Pot'h, 1916	1.13	0.97	0.48	0.93	**3.51**	*3.29*	5.48	4.59	1.16	**11.23**	*11.*	**10.07**	*10.*	...	..
H 9	Stockbridge Early Crop Manure, 1916	1.60	1.35	0.45	0.98	**4.38**	*4.11*	3.62	4.79	1.33	**9.74**	*9.*	**8.41**	*8.*	**0.89**	*1.*

ANALYSES OF LICENSED FERTILIZERS

	BRAND	NITROGEN						PHOSPHORIC ACID							POTASH	
		In nitrates	In ammonia salts	Water soluble organic	Insoluble organic	Total found	Total guaranteed	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Found	Guaranteed
	Bowker Fertilizer Co.—Cont.															
C 15	Superphosphate with Ammo. 1%	0.35	0.28	0.14	0.21	**0.98**	*0.83*	6.48	4.52	0.78	**11.78**	*11.*	**11.00**	*10.*	...	..
C 16	Superphosphate with Ammo. 2%	0.59	0.60	0.28	0.32	**1.79**	*1.65*	6.00	4.36	1.00	**11.36**	*11.*	**10.36**	*10.*	...	..
E 2	Sure Crop Phosphate, 1916	...	0.30	0.29	0.39	**0.98**	*0.82*	5.58	4.82	1.00	**11.40**	*11.*	**10.40**	*10.*	**0.91**	*1.*
	Burlington Rendering Co.															
D 1	Animal Fertilizer	0.53	0.42	0.91	0.88	**2.74**	*2.46*	8.24	2.40	0.38	**11.02**	*11.*	**10.64**	*10.*	...	..
D 2	Grain Fertilizer	0.18	0.35	...	1.05	**1.58**	*1.23*	7.38	3.30	0.64	**11.32**	*11.*	**10.68**	*10.*	...	..
G 10	Grass Fertilizer	1.67	0.72	0.10	2.28	**4.77**	*4.92*	4.88	3.17	1.17	**9.22**	*9.*	**8.05**	*8.*	...	..
D 3	Potato Fertilizer	0.56	0.84	1.00	1.21	**3.61**	*3.28*	8.30	2.87	0.59	**11.76**	*11.*	**11.17**	*10.*	...	..
D 4	Special Fertilizer	0.49	0.49	0.18	1.58	**2.74**	*2.46*	6.84	4.43	0.33	**11.60**	*11.*	**11.27**	*10.*	**1.28**	*1.*
D 5	Vegetable Fertilizer	0.96	1.07	0.21	1.76	**4.00**	*4.1*	7.94	2.98	2.16	**13.08**	*11.*	**10.92**	*10.*	...	..
	The Coe-Mortimer Co.															
F 1	Columbian Corn & Potato Fertilizer, 1916	0.42	0.42	0.39	0.28	**1.51**	*1.23*	5.24	5.60	0.98	**11.82**	*11.*	**10.84**	*10.*	**1.02**	*1.*
E 5	Gold Brand Excelsior Guano, 1916	0.78	0.83	0.34	0.72	**2.67**	*2.47*	3.64	5.62	1.16	**10.42**	*10.*	**9.26**	*9.*	**0.98**	*1.*
F 3	High Grade Ammoniated Superphos., 1916	1.01	0.95	0.22	0.56	**2.74**	*2.47*	6.76	4.64	1.20	**12.60**	*11.*	**11.40**	*10.*	...	..
E 6	New Englander Special, 1916	0.32	0.21	0.13	0.32	**0.98**	*0.82*	4.72	3.87	0.75	**9.34**	*9.*	**8.59**	*8.*	**0.77**	*1.*
F 4	Red Brand Excelsior Guano, 1916	1.32	1.49	0.38	1.05	**4.24**	*4.11*	4.44	4.50	0.82	**9.76**	*9.*	**8.94**	*8.*	**1.05**	*1.*
F 2	Standard Potato Fertilizer, 1916	1.44	1.05	0.18	0.84	**3.51**	*3.29*	4.86	4.89	0.71	**10.46**	*10.*	**9.75**	*9.*	**1.04**	*1.*
J 15	Universal Fertilizer, 1916	0.68	0.55	0.31	0.49	**2.03**	*1.65*	4.96	4.54	1.32	**10.82**	*10.*	**9.50**	*9.*	...	..
F 5	XXX Ammoniated Phosphate, 1916	0.56	0.35	0.32	0.35	**1.58**	*0.82*	4.60	6.01	1.69	**12.30**	*11.*	**10.61**	*10.*	...	..

ANALYSES OF LICENSED FERTILIZERS

	Brand	Nitrogen						Phosphoric Acid							Potash	
		In nitrates	In ammonia salts	Water soluble organic	Insoluble organic	Total found	Total guaranteed	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Found	Guaranteed
	Essex Fertilizer Co.															
E 7	Grain, Grass and Potato Fertilizer......	...	...	0.44	0.44	**0.88**	*0.82*	6.48	5.64	0.60	**12.72**	*13.*	**12.12**	*12.*	...	..
H 7	Manure for Corn, Grain and Grass......	0.51	0.72	1.02	1.05	**3.30**	*3.28*	7.22	2.82	0.88	**10.92**	*11.*	**10.04**	*10.*	**1.13**	*1.*
E 8	Market Garden and Potato Manure......	0.45	0.67	0.57	1.14	**2.83**	*2.87*	6.86	3.02	0.76	**10.64**	*11.*	**9.88**	*10.*	...	..
F 6	Potato Grower	0.45	1.23	0.84	1.72	**4.24**	*4.1*	7.00	3.18	1.38	**11.56**	*11.*	**10.18**	*10.*	...	..
H 8	Special Potato, Grass and Lawn.........	0.40	1.84	0.99	1.75	**4.98**	*4.82*	6.42	1.67	1.13	**9.22**	*9.*	**8.09**	*8.*	...	..
E 9	XXX Fish Fertilizer	0.45	0.46	0.78	0.91	**2.60**	*2.46*	6.52	3.29	1.65	**11.46**	*11.*	**9.81**	*10.*	...	..
	International Agricultural Corporation, Buffalo Fertilizer Works															
D 6	Buffalo Ammoniated Phosphate.........	...	0.76	0.43	0.74	**1.93**	*1.2*	8.14	3.40	0.78	**12.32**	*13.*	**11.54**	*12.*	...	..
F 8	Buffalo Economy	...	0.53	0.42	0.77	**1.72**	*1.6*	6.92	4.53	0.65	**12.10**	*11.*	**11.45**	*10.*	**0.73**	*1.*
D 7	Buffalo Farmers' Choice	...	0.20	0.20	0.51	**0.91**	*0.8*	7.48	4.06	0.56	**12.10**	*11.*	**11.54**	*10.*	...	..
D 8	Buffalo General Favorite	...	0.46	0.29	0.58	**1.33**	*0.8*	5.78	2.82	0.76	**9.36**	*9.*	**8.60**	*8.*	**0.94**	*1.*
D 9	Buffalo High Grade Manure	1.40	0.63	0.39	0.95	**3.37**	*3.3*	6.16	3.26	1.00	**10.42**	*9.*	**9.42**	*8.*	**0.87**	*1.*
F 7	Buffalo New England Special	...	0.48	0.47	0.70	**1.65**	*1.6*	7.72	4.10	1.70	**13.52**	*11.*	**11.82**	*10.*	...	..
D 10	Buffalo Top Dresser	2.68	0.86	0.61	1.05	**5.20**	*5.8*	3.52	3.82	1.32	**8.66**	*7.*	**7.34**	*6.*	...	..
D 11	Buffalo Vegetable and Potato	...	0.90	0.57	1.16	**2.63**	*2.5*	7.76	3.24	1.14	**12.14**	*11.*	**11.00**	*10.*	...	..
	Listers' Agricultural Chemical Works															
K 8	Atlas Brand Fertilizer, 1916............	1.12	1.62	0.95	1.05	**4.74**	*4.11*	4.48	3.31	2.72	**10.51**	*9.*	**7.79**	*8.*	...	..
F 16	Corn and Potato Fertilizer, 1916.........	...	1.23	0.56	0.53	**2.32**	*2.06*	2.66	4.70	2.23	**9.59**	*9.*	**7.36**	*8.*	**0.86**	*1.*
K 9	Crescent Ammo. Superphosphate, 1916...	...	0.56	0.38	0.88	**1.82**	*1.65*	5.62	3.91	2.75	**12.28**	*11.*	**9.58**	*10.*	...	..

ANALYSES OF LICENSED FERTILIZERS

	BRAND	NITROGEN						PHOSPHORIC ACID							POTASH	
		In nitrates	In ammonia salts	Water soluble organic	Insoluble organic	Total found	Total guaranteed	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Found	Guaranteed
	Listers' Agricultural Chemical Works—Cont.															
H 5	Excelsior Guano, 1916	...	0.97	0.61	1.30	**2.88**	*2.47*	6.20	4.47	2.69	**13.36**	*11.*	**10.67**	*10.*	...	..
G 16	High Gr. Special for Spring Crops, 1916	...	0.90	0.60	0.53	**2.08**	*2.06*	6.64	3.94	1.22	**11.80**	*11.*	**10.58**	*10.*	**0.82**	*1.*
H 3	High Grade Topdresser, 1916	3.33	3.79	0.46	0.84	**8.42**	*8.23*	3.92	2.10	0.98	**7.00**	*6.*	**6.02**	*5.*	**0.74**	*1.*
H 4	Plant Food, 1916	...	0.14	0.35	0.60	**1.09**	*0.82*	7.56	4.02	1.20	**12.78**	*11.*	**11.58**	*10.*	...	..
G 15	Potato Manure, 1916	1.05	1.69	0.52	0.60	**3.86**	*4.11*	4.18	4.71	1.87	**10.76**	*9.*	**8.89**	*8.*	**0.77**	*1.*
G 13	Revised Vt. Corn & Potato Fert., 1916	...	0.35	0.14	0.49	**0.98**	*0.82*	4.72	4.30	1.02	**10.04**	*9.*	**9.02**	*8.*	**0.92**	*1.*
K 16	Special Potato Fertilizer, 1916	1.01	1.48	0.81	1.05	**4.35**	*4.11*	1.44	9.12	2.64	**13.20**	*11.*	**10.56**	*10.*	...	..
H 1	Standard Grass Fertilizer, 1916	0.66	1.44	0.28	0.25	**2.63**	*2.47*	6.52	3.21	0.71	**10.44**	*10.*	**9.73**	*9.*	**0.86**	*1.*
G 14	Success Fertilizer, 1916	...	0.44	0.22	0.60	**1.26**	*1.23*	7.60	4.47	1.03	**13.10**	*11.*	**12.07**	*10.*	**0.89**	*1.*
H 2	Superior Ammo. Superphos., 1916	0.92	0.97	0.57	1.05	**3.51**	*3.29*	4.24	5.74	2.74	**12.72**	*11.*	**9.98**	*10.*	...	..
	Lowell Fertilizer Co.															
F 9	Animal Brand for All Crops	0.52	0.67	0.57	1.19	**2.95**	*2.89*	6.84	3.54	0.86	**11.24**	*11.*	**10.38**	*10.*	...	..
F 10	Bone Fert. for Corn, Grain, Grass & Veg.	0.17	0.32	0.68	0.88	**2.05**	*2.05*	6.32	3.70	1.38	**11.40**	*11.*	**10.02**	*10.*	...	..
F 11	Corn and Vegetable Manure	0.49	1.09	0.88	1.54	**4.00**	*4.1*	7.16	2.50	1.70	**11.36**	*11.*	**9.66**	*10.*	...	..
F 12	Empress Brand for Corn, Pot. & Grain	...	...	0.67	0.56	**1.23**	*1.25*	6.92	2.73	1.34	**10.99**	*11.*	**9.65**	*10.*	...	..
H 6	Market Garden, Special Grass & Lawn	0.40	2.09	0.88	1.61	**4.98**	*4.82*	4.86	3.59	0.95	**9.40**	*9.*	**8.45**	*8.*	...	..
F 13	Potato Manure	0.53	0.42	0.70	0.91	**2.56**	*2.46*	7.04	2.98	1.71	**11.78**	*11.*	**10.02**	*10.*	...	..
F 14	Potato Phosphate	0.45	0.88	0.98	1.09	**3.40**	*3.28*	7.62	2.54	0.88	**11.04**	*11.*	**10.16**	*10.*	...	..
F 15	Sterling Phosphate	...	...	0.56	0.35	**0.91**	*0.82*	10.12	2.57	1.63	**14.32**	*13.*	**12.69**	*12.*	...	..

ANALYSES OF LICENSED FERTILIZERS

	Brand	Nitrogen						Phosphoric Acid							Potash	
		In nitrates	In ammonia salts	Water soluble organic	Insoluble organic	Total found	Total guaranteed	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Found	Guaranteed
	National Fertilizer Co.															
E 10	Eureka Potato Fertilizer, 1916	0.86	0.86	0.42	0.60	**2.74**	*2.47*	4.98	4.64	1.00	**10.62**	*10.*	**9.62**	*9.*	**0.96**	*1.*
J 16	Potato Phosphate, 1916	0.88	0.56	0.35	0.49	**2.28**	*2.06*	4.08	4.72	1.06	**9.86**	*9.*	**8.80**	*8.*	**1.02**	*1.*
E 11	Special Complete Fertilizer, 1916	1.25	1.07	0.36	0.69	**3.37**	*3.29*	4.26	5.06	1.06	**10.38**	*10.*	**9.32**	*9.*	**0.97**	*1.*
E 12	Universal Fertilizer, 1916	0.36	0.34	0.23	0.23	**1.16**	*0.82*	4.58	4.52	0.90	**10.00**	*9.*	**9.10**	*8.*	**1.12**	*1.*
	New England Fertilizer Co.															
K 11	Complete Manure, Potatoes & Vegetables	0.40	0.83	1.12	1.09	**3.44**	*3.28*	7.64	2.57	1.19	**11.40**	*11.*	**10.21**	*10.*	**1.22**	*1.*
K 12	Corn and Grain Fertilizer	...	...	0.74	0.63	**1.37**	*1.23*	7.00	2.85	1.65	**11.50**	*11.*	**9.85**	*10.*	...	..
K 10	Corn Phosphate	...	0.39	0.84	0.98	**2.21**	*2.05*	6.56	3.26	1.75	**11.57**	*11.*	**9.82**	*10.*	...	..
H 12	Potato Fertilizer	0.47	0.44	0.74	0.88	**2.58**	*2.46*	4.08	6.24	0.94	**11.26**	*11.*	**10.32**	*10.*	...	..
H 10	Potato and Vegetable	...	2.02	1.14	1.05	**4.21**	*4.1*	7.22	2.61	1.13	**10.96**	*11.*	**9.83**	*10.*	...	..
H 11	Superphosphate for All Crops	0.50	0.69	0.92	1.05	**3.16**	*2.87*	6.54	4.17	0.87	**11.58**	*11.*	**10.71**	*10.*	...	..
	Parmenter & Polsey Fertilizer Co.															
D 12	Corn and Grain Fertilizer	...	...	0.44	0.44	**0.88**	*0.82*	6.64	5.68	0.40	**12.72**	*12.*	**12.32**	*12.*	...	..
L 5	Grain Grower	0.23	0.30	0.84	0.95	**2.32**	*1.23*	6.58	3.50	1.16	**11.24**	*11.*	**10.08**	*10.*	...	..
D 13	Plymouth Rock Brand Fertilizer	0.49	0.67	0.63	1.16	**2.95**	*2.88*	7.44	3.05	0.83	**11.32**	*11.*	**10.49**	*10.*	**1.01**	*1.*
L 3	Potato and Vegetable	0.35	1.97	0.95	1.68	**4.95**	*4.97*	6.06	2.09	1.21	**9.36**	*9.*	**8.15**	*8.*	...	..
D 14	Potato Fertilizer	...	0.35	0.87	0.88	**2.10**	*2.05*	7.10	3.60	1.32	**12.02**	*11.*	**10.70**	*10.*	...	..
L 1	Potato Phosphate	0.47	0.90	1.09	1.05	**3.51**	*3.28*	7.24	2.89	1.01	**11.14**	*11.*	**10.13**	*10.*	...	..
L 4	Special Potato	0.40	1.21	0.99	1.68	**4.28**	*4.1*	7.12	2.94	1.88	**11.94**	*11.*	**10.06**	*10.*	...	..
L 2	Star Brand Superphosphate	0.46	0.42	0.70	0.88	**2.46**	*2.46*	6.56	3.37	1.63	**11.56**	*11.*	**9.98**	*10.*	...	..

ANALYSES OF LICENSED FERTILIZERS

	Brand	Nitrogen						Phosphoric Acid							Potash	
		In nitrates	In ammonia salts	Water soluble organic	Insoluble organic	Total found	Total guaranteed	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Found	Guaranteed
	Reading Bone Fertilizer Co.															
E 13	All Crop Special	...	0.70	0.63	0.60	**1.93**	*1.64*	5.02	4.32	2.68	**12.02**	*11.*	**9.34**	*10.*	...	..
E 16	Farmers' Tankage & Potash for Corn, etc.	...	0.14	0.09	0.65	**0.88**	*0.82*	0.64	9.14	2.74	**12.52**	*11.*	**9.78**	*10.*	**0.87**	*1.*
H 14	Never Fail Crop Grower	...	0.13	0.46	0.53	**1.12**	*0.82*	4.20	6.73	1.41	**12.34**	*11.*	**10.93**	*10.*	...	..
H 13	Prize Winner	...	1.37	0.49	0.49	**2.35**	*2.46*	5.06	3.53	1.46	**10.05**	*10.*	**8.59**	*9.*	...	..
E 14	Special Grain and Grass Producer	...	0.09	0.17	0.72	**0.98**	*0.82*	3.70	3.59	2.17	**9.46**	*8.*	**7.29**	*7.*	...	..
E 15	Potato and Tobacco Manure	...	0.27	0.36	0.42	**1.05**	*0.82*	6.68	5.71	1.79	**14.18**	*13.*	**12.39**	*12.*	...	..
L 7	Truck, Fruit, Tree, Vine, Potato, etc.	...	1.83	0.84	0.70	**3.37**	*3.28*	4.12	3.72	2.31	**10.15**	*9.*	**7.84**	*8.*	...	..
	Rogers & Hubbard Co.															
G 1	All Soils—All Crops Phosphate	2.14	0.07	0.81	0.70	**3.72**	*3.3*	2.56	4.18	2.42	**9.16**	*9.*	**6.74**	*7.*	...	..
G 2	Complete Phosphate	...	...	0.63	0.56	**1.19**	*1.*	4.92	4.32	2.40	**11.64**	*11.*	**9.24.**	*9.*	...	..
G 3	Fertilizer for Oats and Topdressing	4.75	0.16	0.42	0.74	**6.07**	*6.*	0.16	8.14	6.62	**14.92**	*12.*	**8.30**	*6.*	...	..
G 4	Potato Phosphate	0.73	0.11	0.77	0.56	**2.17**	*2.*	4.60	8.04	3.16	**15.80**	*15.*	**12.64**	*13.*	...	..
G 5	Soluble Corn and General Crops Manure	1.47	0.14	0.50	0.63	**2.74**	*2.5*	2.68	6.22	5.32	**14.22**	*12.*	**8.90**	*10.*	...	..
J 5	Soluble Potato Manure	2.01	0.27	0.63	1.51	**4.42**	*4.25*	0.44	9.94	6.50	**16.88**	*16.*	**10.38**	*10.*	**1.00**	*1.*
	F. S. Royster Guano Co.															
J 6	Cuckoo Crop Grower	...	0.48	0.05	0.42	**0.95**	*0.82*	4.16	4.12	0.76	**9.04**	*8.5*	**8.28**	*8.*	...	..
J 7	Curfew Ammoniated Superphosphate	...	1.76	0.31	1.51	**3.58**	*3.29*	6.04	2.55	0.89	**9.48**	*8.5*	**8.59**	*8.*	...	..
J 8	Defender Fertilizer	...	1.12	0.53	1.58	**3.23**	*3.29*	3.62	4.08	2.14	**9.84**	*8.5*	**7.70**	*8.*	**0.94**	*1.*
J 9	Drillwell Phosphate	...	0.79	0.58	1.23	**2.60**	*2.47*	3.44	4.13	1.77	**9.34**	*8.5*	**7.57**	*8.*	**1.06**	*1.*

ANALYSES OF LICENSED FERTILIZERS

	Brand	Nitrogen						Phosphoric Acid							Potash	
		In nitrates	In ammonia salts	Water soluble organic	Insoluble organic	Total found	Total guaranteed	Soluble	Reverted	Insoluble	Total found	Total guaranteed	Available found	Available guaranteed	Found	Guaranteed
	F. S. Royster Guano Co.—Cont.															
J 14	Goodwill Ammoniated Superphosphate..	...	2.00	0.18	1.68	**3.86**	*4.11*	5.98	2.95	1.23	**10.16**	*8.5*	**8.98**	*8.*	...	..
J 13	Innovation Ammoniated Superphosphate.	...	1.46	0.05	1.05	**2.56**	*2.47*	6.86	2.56	0.82	**10.24**	*8.5*	**9.42**	*8.*	...	..
J 10	Log Cabin Guano	...	1.76	0.66	1.72	**4.14**	*4.11*	3.32	4.47	2.41	**10.20**	*8.5*	**7.79**	*8.*	**0.99**	*1.*
J 11	Logical Compound	...	0.41	0.50	0.77	**1.68**	*1.65*	3.20	5.04	0.92	**9.16**	*8.5*	**8.24**	*8.*	**0.95**	*1.*
J 12	Penguin Ammoniated Superphosphate...	...	0.72	0.54	0.60	**1.86**	*1.65*	6.88	5.06	1.92	**13.86**	*10.5*	**11.94**	*10.*	...	..
	J. W. Sanborn															
L 8	Prof. Sanborn's for Grass and Grain.....	1.89	0.28	1.20	1.30	**4.67**	*4.94*	0.36	6.78	3.52	**10.66**	*9.*	**7.14**	*8.*	...	..
J 2	Prof. Sanborn's for Hill and Drill.......	...	0.20	0.68	1.61	**2.49**	*2.47*	2.64	5.06	3.48	**11.18**	*9.*	**7.70**	*8.*	...	..
J 1	Prof. Sanborn's for Potatoes and Corn...	...	0.20	0.78	2.32	**3.30**	*3.29*	2.86	4.34	3.00	**10.20**	*9.*	**7.20**	*8.*	...	..
	Sanderson Fertilizer & Chemical Co.															
G 6	Atlantic Coast Bone, Fish & Potash, 1916	...	0.07	0.56	1.05	**1.68**	*1.64*	1.12	9.04	1.64	**11.80**	*10.*	**10.16**	*9.*	**1.05**	*1.*
G 7	Corn Superphosphate, 1916.............	...	0.07	0.81	1.05	**1.93**	*1.64*	2.38	8.84	1.24	**12.46**	*11.*	**11.22**	*10.*	**1.25**	*1.*
G 8	Potato Manure, 1916	...	0.16	0.86	1.44	**2.46**	*2.06*	3.00	6.59	2.29	**11.88**	*9.*	**9.59**	*8.*	**1.12**	*1.*
	Virginia-Carolina Chemical Co.															
D 15	Ammoniated Bone Phos. for All Crops...	...	0.23	0.36	1.27	**1.86**	*1.65*	4.52	5.26	2.28	**12.06**	*11.*	**9.78**	*10.*	...	..
G 9	High Grade Corn and Vegetable Comp...	0.80	0.11	0.39	1.47	**2.77**	*2.47*	4.34	4.22	1.62	**10.18**	*9.*	**8.56**	*8.*	***1.24**	*1.*
D 16	Owl Brand Potato Fertilizer...........	...	0.34	0.67	0.81	**1.82**	*1.65*	6.08	2.54	1.94	**10.56**	*9.*	**8.62**	*8.*	***0.94**	*1.*
E 1	Plow Brand Fertilizer	...	0.35	0.17	0.46	**0.98**	*0.82*	6.54	1.64	1.18	**9.36**	*9.*	**8.18**	*8.*	***1.18**	*1.*
K 14	20th Century Pot. Man. with 2% Potash.	1.45	0.23	0.99	1.75	**4.42**	*4.12*	2.08	6.41	1.83	**10.32**	*9.*	**8.49**	*8.*	***2.48**	*2.*

*Potash as sulphate.

CONCERNING THE TABLES ON PAGES 45 TO 49

There have been those who have found that the tables of analyses printed in the annual bulletin were somewhat complicated and difficult to understand, that comparisons were not readily made, and they have pled for simpler, more direct statements. The writers have felt that full statements as to the analytical data were really needed—and they still feel so. They have felt that the ideas could be readily grasped if one set himself seriously to study the matter. However, recognizing that publicity is the most effective weapon in their hands in the enforcement of the law and that anything which will tend to clarify the situation in the buyer's mind is worth while, they have formulated an additional and simpler statement as to the results of inspection. This is set forth on pages 45 to 49. This form is used tentatively this year. In the theatrical parlance it is "tried on the dog." The writers are not at all sure that it will be in any respect a help. It may be a hindrance. That this particular form will be followed in future years they cannot guarantee. It simply represents their sincere attempt to reduce the analytical statements to their simplest terms.

In order to set forth the meaning of these new tables a few words of explanation seem necessary.

The law requires a manufacturer to state on each package how much plant food he is selling. Long years of experience have indicated clearly that manufacturers rarely give more than they promise; on the average of late years it is not more than seven percent. Such being the case, the buyer is interested primarily in knowing whether or not the promise which has been made has been kept.

The first three figures in the table, reading horizontally following the brand name, indicate what the promise is; and the word following, usually "Yes," rarely "No," tells in this laconic, straightforward fashion whether or not the promise has been kept.

The remaining words and figures, other than the last figure in the horizontal line, have to do with *the quality of the nitrogen* which is furnished. This is an important item of information. In the first place *by the use of the words "Passed" or "Inferior" the character of the organic nitrogen used is indicated.* The former word is used whenever the analysis indicated a good or passable grade; the latter when it did not. The next three horizontal statements in terms of figures indicate *the proportions of the total nitrogen present in the several forms;* of nitrate nitrogen—derived from nitrate of soda; of ammonia—derived usually from sulphate of ammonia; and of organic nitrogen—derived usually from materials like tankage, dried blood, dried fish, and other residues of a nitrogenous character. These figures are expressed in terms of tenths, and the three added always equal unity. Thus if, for example, a set of figures reads horizontally .4 .3 .3, it means that the nitrogen was furnished in those proportions in the form of nitrate, in the form of ammonia salts and in the form of organic nitrogen; 4 parts in 10 as nitrate, 3 parts in 10 as ammonia salts, and 3 parts in 10 as organic matter. If, as is often the case, no figure whatever appears, it should be understood that no nitrogen in the form indicated by the blank was used in the goods. This seems a simple, straightforward statement. It does not indicate whether the promise was high or low; that is betrayed by the manufacturer's guaranty, the first figures in the horizontal column. It simply shows what sort of material the manufacturer has used to furnish the nitrogen.

The last figure, reading horizontally, indicates in terms of a decimal fraction, ***what part of the total phosphoric acid is furnished in available form.***

So far as potash is concerned the manufacturer's guaranty column serves the purpose for this year.

CONDENSED STATEMENT AS TO GUARANTIES AND ANALYSES

	BRAND	Guaranties			Guaranty met?	Quality organic nitrogen?	Nitrogen*			Proportion of total phosphoric acid in available form
		Nitrogen	Available phosphoric acid	Potash			As nitrates	As ammonia salts	Organic	
	American Agricultural Chemical Co.									
K 3	AA Potato Grower, 1916	3.7	8	1	Yes	Passed	.5	..	.5	.8
A 1	Ammoniated Fertilizer A	0.8	10	..	"	"	.4	.3	.3	.9
A 2	Ammoniated Fertilizer AA	1.7	10	..	"	"	.4	.3	.3	.8
A 3	Ammoniated Fertilizer AAA	2.5	10	..	"	"	.4	.3	.3	.9
A 4	Ammoniated Fertilizer AAAA	3.3	10	..	"	"	.3	.3	.4	.8
K 2	General Crop Grower, 1916	1.7	9	1	"	"	.4	.3	.3	.8
A 5	Gr. and Lawn Topdressing, 1916	3.7	8	1	"	"	.4	.3	.3	.9
A 6	High Grade Fertilizer, 1916	2.5	8	1	"	"	.3	.3	.4	.8
K 1	Spec. Gr. & Gard. Mixture, 1916	8.3	5	1	"	"	.3	.5	.2	.8
A 7	Topdresser, 1916	4.1	8	1	"	"	.4	.3	.3	.9
	(*Bradley Fertilizer Co. Brands*)									
A 12	Circle Br. Bone and Pot., 1916	1.7	9	1	Yes	Passed	.4	.2	.4	.9
A 8	Com. Man. for Corn & Gr., 1916	3.3	9	1	"	"	.4	.3	.3	.9
A 9	Com. Man. for Pot. & Veg., 1916	3.3	9	1	"	"	.4	.3	.3	.9
A 10	Com. Man. for Topdr. Gr. & Gr.	4.1	8	1	"	"	.4	.3	.3	.9
A 11	Corn Phosphate, 1916	1.7	10	1	"	"	.4	.3	.3	.9
A 13	Eclipse Phosphate, 1916	1.2	10	1	"	"	.4	.2	.4	.9
A 14	High Gr. Pot. & Root Spec., 1916	1.7	10	1	"	"	.4	.3	.3	.9
A 16	Potato Fertilizer, 1916	2.1	8	1	"	"	.4	.2	.4	.9
A 15	Potato Manure, 1916	2.5	9	1	"	"	.4	.3	.3	.9
B 1	XL Superphos. of Lime, 1916	2.5	9	1	"	"	.4	.3	.3	.9
	(*Cleveland Dryer Co. Brands*)									
B 4	General Crop Fertilizer, 1916	.8	8	1	Yes	Passed	.4	.3	.3	.9
B 3	Potato Phosphate, 1916	2.1	8	1	"	"	.4	.2	.4	.9
B 2	Superphosphate, 1916	1.7	10	1	"	"	.4	.2	.4	.9
	(*Crocker Fertilizer & Chemical Co. Brands*)									
G 11	Ammo'd Corn Phosphate, 1916	2.1	8	1	Yes	Passed	.3	.3	.4	.9
B 6	New Rival Ammo'd Super., 1916	.8	10	1	"	"	.4	.3	.3	.9
B 5	Pot., Hop & Tob. Fertilizer, 1916	2.1	10	1	"	"	.4	.3	.3	.9
G 12	Spec. Potato Fertilizer, 1916	3.3	10	1	"	"	.4	.3	.3	.9
	(*Darling Fertilizer Co. Brands*)									
B 7	Farm Favorite, 1916	1.7	10	1	Yes	Passed	.3	.3	.4	.9
B 8	General Fertilizer, 1916	.8	8	1	"	"	.3	.3	.4	.9
	(*Great Eastern Fertilizer Co. Brands*)									
B 9	General Fertilizer, 1916	.8	8	1	Yes	Passed	.3	.3	.4	.9
B 10	High Gr. Potato Fertilizer, 1916	3.3	9	1	"	"	.3	.3	.4	.9
B 11	Northern Corn Special, 1916	2.1	8	1	"	"	.3	.3	.4	.9
B 12	Potato Manure, 1916	2.1	10	1	"	"	.3	.3	.4	.9
	(*Pacific Guano Co. Brands*)									
B 14	Nobsque Guano, 1916	.8	8	1	Yes	Passed	.3	.2	.5	.9
L 6	Potato Special, 1916	2.1	8	1	"	"	.3	.3	.4	.9
B 13	Soluble Pacific Guano, 1916	1.7	10	1	"	"	.4	.3	.3	.9

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*This heading should be construed to read:—Proportion of total nitrogen present in the several forms as stated below.

CONDENSED STATEMENT AS TO GUARANTIES AND ANALYSES

	BRAND	Guaranties			Guaranty met?	Quality organic nitrogen?	Nitrogen*				Proportion of total phosphoric acid in available form
		Nitrogen	Available phosphoric acid	Potash			As nitrates	As ammonia salts	Organic		
	American Agricultural Chemical Co.—Continued										
	(Quinnipiac Co. Brands)										
B 15	Corn Manure, 1916	1.7	10	1	Yes	Passed	.3	.3	.4	..	.9
K 13	Market Garden Manure, 1916	3.3	9	1	"	"	.3	.4	.3	..	.9
B 16	Potato Phosphate, 1916	2.1	8	1	"	"	.3	.3	.4	..	.9
	(Read Fertilizer Co. Brands)										
J 4	Farmers' Fr. Superphos., 1916	2.1	8	1	Yes	Passed	.3	.3	.4	..	.9
C 1	H. G. Farmers' Fr. Super. 1916	3.3	9	1	"	"	.4	.3	.3	..	.9
J 3	Practical Fertilizer, 1916	.8	8	1	"	"	.3	.2	.5	..	.9
	(Williams & Clark Fertilizer Co. Brands)										
C 3	Americus Corn Phosphate, 1916	1.7	10	1	Yes	Passed	.4	.3	.3	..	.9
C 2	Americus H. G. Spec. for Pot. & Root Crops, 1916	3.3	9	1	"	"	.4	.3	.3	..	.9
C 4	Americus Potato Manure, 1916	2.1	8	1	"	"	.4	.3	.3	..	.9
K 15	Royal Bone Phosphate, 1916	1.2	10	1	"	"	.3	.2	.5	..	.9
C 5	Special Prolific Crop Producer	.8	9	1	No	"	.3	.3	.4	..	.9
	Armour Fertilizer Works										
K 7	Five, Eight, One	4.1	8	1	Yes	Passed	..	.2	.8	..	.8
C 9	Four, Eight, One	3.3	8	1	"	"	..	.4	.6	..	.9
K 4	Four, Eight, Zero	3.3	8	0	"	"	..	.3	.7	..	.9
K 5	One and one-half, Nine, Zero	1.2	9	0	"	"	..	.3.	7	..	.9
C 8	Three, Eight, One	2.5	8	1	"	"	..	.4	.6	..	.9
K 6	Two and one-half, Eight, Two	2.1	8	2	"	"	.1	.3	.6	..	.9
C 7	Two, Eight, One	1.7	8	1	No	"	..	.1	.9	..	.9
C 6	Two, Eleven, Zero	1.7	11	0	Yes	"	..	.3	.7	..	.9
C 10	Wheat, Corn, Oats Special	.8	7	1	"	"	..	.2	.8	..	.9
	Bowker Fertilizer Co.										
H 15	All Round Fertilizer, 1916	2.1	11	1	Yes	Passed	.3	.3	.4	..	.9
C 11	Brighton Phosphate	.8	8	0	"	"	.4	.3	.3	..	.9
E 4	Corn Phosphate, 1916	1.7	10	1	"	"	.2	.4	.4	..	.9
H 16	Farm and Garden Phos., 1916	1.7	11	1	"	"	.3	.2	.5	..	.9
E 3	Hill and Drill Phosphate, 1916	2.5	9	1	"	"	.3	.3	.4	..	.9
C 12	Potato Phosphate, 1916	1.7	10	1	"	"	.4	.3	.3	..	.9
C 13	Stockbridge Gen. Cr. Man., 1916	3.3	9	1	"	"	.3	.3	.4	..	.9
C 14	Stockbridge Cereal Manure without Potash, 1916	3.3	10	0	"	"	.3	.3	.4	..	.9
H 9	Stockbridge Early Crop Man., 1916	4.1	8	1	"	"	.4	.3	.3	..	.9
C 15	Superphos. with Ammo. 1%	.8	10	0	"	"	.4	.3	.3	..	.9
C 16	Superphos. with Ammo. 2%	1.7	10	0	"	"	.3	.3	.4	..	.9
E 2	Sure Crop Phosphate, 1916	.8	10	1	"	"	..	.3	.7	..	.9

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CONDENSED STATEMENT AS TO GUARANTIES AND ANALYSES

	Brand	Guaranties			Guaranty met?	Quality organic nitrogen?	Nitrogen*			Proportion of total phosphoric acid in available form
		Nitrogen	Available phosphoric acid	Potash			As nitrates	As ammonia salts	Organic	
	Burlington Rendering Co.									
D 1	Animal Fertilizer	2.5	10	0	Yes	Passed	.2	.3	.5	1.0
D 2	Grain Fertilizer	1.2	10	0	"	"	.1	.2	.7	.9
G 10	Grass Fertilizer	4.9	8	0	"	"	.4	.2	.4	.9
D 3	Potato Fertilizer	3.3	10	0	"	"	.2	.3	.5	1.0
D 4	Special Fertilizer	2.5	10	1	"	"	.3	.3	.4	1.0
D 5	Vegetable Fertilizer	4.1	10	0	"	"	.2	.3	.5	.8
	The Coe-Mortimer Co.									
F 1	Columbian Corn & Pot., 1916	1.2	10	1	Yes	Passed	.3	.3	.4	.9
E 5	Gold Br. Excelsior Guano, 1916	2.5	9	1	"	"	.3	.3	.4	.9
F 3	H. G. Ammo. Superphos., 1916	2.5	10	0	"	"	.4	.3	.3	.9
E 6	New Englander Special, 1916	.8	8	1	"	"	.3	.2	.5	.9
F 4	Red Br. Excelsior Guano, 1916	4.1	8	1	"	"	.3	.4	.3	.9
F 2	Standard Potato Fert., 1916	3.3	9	1	"	"	.4	.3	.3	.9
J 15	Universal Fertilizer, 1916	1.7	9	0	"	"	.3	.3	.4	.9
F 5	XXX Ammo. Phosphate., 1916	.8	10	0	"	"	.4	.2	.4	.9
	Essex Fertilizer Co.									
E 7	Grain, Grass & Potato Fert.	.8	12	0	Yes	Passed	..	..	1.0	1.0
H 7	Man. for Corn, Grain & Grass	3.3	10	1	"	"	.2	.2	.6	.9
E 8	Market Garden & Potato Man.	2.9	10	0	"	"	.2	.3	.5	.9
F 6	Potato Grower	4.1	10	0	"	"	.1	.3	.6	.9
H 8	Special Potato, Grass & Lawn	4.8	8	0	"	"	.1	.4	.5	.9
E 9	XXX Fish Fertilizer	2.5	10	0	"	"	.2	.2	.6	.9
	International Agricultural Corporation, Buffalo Fertilizer Works									
D 6	Buffalo Ammoniated Phosphate	1.2	12	0	Yes	Passed	..	.4	.6	.9
F 8	Buffalo Economy	1.6	10	1	"	"	..	.3	.7	.9
D 7	Buffalo Farmers' Choice	.8	10	0	"	"	..	.2	.8	1.0
D 8	Buffalo General Favorite	.8	8	1	"	"	..	.3	.7	.9
D 9	Buffalo High Grade Manure	3.3	8	1	"	"	.4	.2	.4	.9
F 7	Buffalo New England Special	1.6	10	0	"	"	..	.3	.7	.9
D 10	Buffalo Top Dresser	5.8	6	0	"	"	.5	.2	.3	.8
D 11	Buffalo Vegetable and Potato	2.5	10	0	"	"	..	.3	.7	.9
	Listers' Agricultural Chemical Works									
K 8	Atlas Brand Fertilizer, 1916	4.1	8	0	Yes	Passed	.2	.3	.5	.7
F 16	Corn and Potato Fertilizer, 1916	2.1	8	1	No	"	..	.5	.5	.8
K 9	Crescent Ammo. Super., 1916	1.7	10	0	"	"	..	.3	.7	.8
H 5	Excelsior Guano, 1916	2.5	10	0	Yes	"	..	.3	.7	.8
G 16	H. G. Spec. for Spr. Crops, 1916	2.1	10	1	"	"	..	.4	.6	.9
H 3	High Grade Topdresser, 1916	8.2	5	1	"	"	.4	.4	.2	.9
H 4	Plant Food, 1916	.8	10	0	"	Inferior	..	.1	.9	.9
G 15	Potato Manure, 1916	4.1	8	1	"	Passed	.3	.4	.3	.8
G 13	Revised Vt. Corn & Potato, 1916	.8	8	1	"	"	..	.4	.6	.9
K 16	Special Potato Fertilizer, 1916	4.1	10	0	"	"	.2	.3	.5	.8

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	BRAND	Guaranties			Guaranty met?	Quality organic nitrogen?	Nitrogen*			Proportion of total phosphoric acid in available form
		Nitrogen	Available phosphoric acid	Potash			As nitrates	As ammonia salts	Organic	
	Listers' Agricultural Chemical Works—Continued									
H 1	Standard Grass Fertilizer, 1916	2.5	9	1	Yes	Passed	.2	.6	.2	.. .9
G 14	Success Fertilizer, 1916	1.2	10	1	"	"	..	.4	.6	.. .9
H 2	Super. Ammo. Superphos., 1916	3.3	10	0	"	"	.3	.3	.4	.. .8
	Lowell Fertilizer Co.									
F 9	Animal Brand for All Crops	2.9	10	0	Yes	Passed	.2	.2	.6	.. .9
F 10	Bone Fertilizer for Corn, Grain, Grass and Vegetables	2.1	10	0	"	"	.1	.2	.7	.. .9
F 11	Corn and Vegetable Manure	4.1	10	0	No	"	.1	.3	.6	.. .9
F 12	Empress Brand for Corn, Potatoes and Grain	1.3	10	0	No	"	..	..	1.0	.. .9
H 6	Mkt. Gard., Spec. Grass, Lawn	4.8	8	0	Yes	"	.1	.4	.5	.. .9
F 13	Potato Manure	2.5	10	0	"	"	.2	.2	.6	.. .8
F 14	Potato Phosphate	3.3	10	0	"	"	.1	.3	.6	.. .9
F 15	Sterling Phosphate	.8	12	0	"	"	..	..	1.0	.. .9
	National Fertilizer Co.									
E 10	Eureka Potato Fertilizer, 1916	2.5	9	1	Yes	Passed	.3	.3	.4	.. .9
J 16	Potato Phosphate, 1916	2.1	8	1	"	"	.4	.2	.4	.. .9
E 11	Special Complete Fert., 1916	3.3	9	1	"	"	.4	.3	.3	.. .9
E 12	Universal Fertilizer, 1916	.8	8	1	"	"	.3	.3	.4	.. .9
	New England Fertilizer Co.									
K 11	Complete Manure, Potato & Veg.	3.3	10	1	Yes	Passed	.1	.2	.7	.. .9
K 12	Corn and Grain Fertilizer	1.2	10	0	"	"	..	..	1.0	.. .9
K 10	Corn Phosphate	2.1	10	0	"	"	..	.2	.8	.. .8
H 12	Potato Fertilizer	2.5	10	0	"	"	.2	.2	.6	.. .9
H 10	Potato and Vegetable	4.1	10	0	"	"	..	.5	.5	.. .9
H 11	Superphosphate for All Crops	2.9	10	0	"	"	.2	.3	.5	.. .9
	Parmenter & Polsey Fertilizer Co.									
D 12	Corn and Grain Fertilizer	.8	12	0	Yes	Passed	..	..	1.0	.. 1.0
L 5	Grain Grower	1.2	10	0	"	"	.1	.1	.8	.. .9
D 13	Plymouth Rock Brand Fertilizer	2.9	10	1	"	"	2.	.2	.6	.. .9
L 3	Potato and Vegetable	5.	8	0	"	"	.1	.4	.5	.. .9
D 14	Potato Fertilizer	2.1	10	0	"	"	..	.2	.8	.. .9
L 1	Potato Phosphate	3.3	10	0	"	"	.1	.3	.6	.. .9
L 4	Special Potato	4.1	10	0	"	"	.1	.3	.6	.. .8
L 2	Star Brand Superphosphate	2.5	10	0	"	"	.2	.2	.6	.. .9
	Reading Bone Fertilizer Co.									
H 13	Prize Winner	2.5	9	0	No	Passed	..	.6	.4	.. .9
E 16	Farmers' Tankage and Potash for Corn, Grain and Grass	.8	10	1	Yes	"	..	.2	.8	.. .8
H 14	Never Fail Crop Grower	.8	10	0	"	"	..	.1	.9	.. .9

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	Brand	Guaranties			Guaranty met?	Quality organic nitrogen?	Nitrogen*			Proportion of total phosphoric acid in available form
		Nitrogen	Available phosphoric acid	Potash			As nitrates	As ammonia salts	Organic	
	Reading Bone Fertilizer Co.—Continued									
H 13	Prize Winner	2.5	9	0	No	Passed	..	.6	.4	.9
E 14	Special Grain & Grass Producer	.8	7	0	Yes	"	..	.1	.9	.8
E 15	Potato and Tobacco Manure	.8	12	0	"	"	..	.3	.7	.9
L 7	Truck, Fruit, Tree, Vine, Potato & Tobacco Grower	3.3	8	0	"	"	..	.5	.5	.8
	Rogers & Hubbard Co.									
G 1	All Soils—All Crops Phosphate	3.3	7	0	Yes	Passed	.6	..	.4	.7
G 2	Complete Phosphate	1.	9	0	"	"	..	..	1.0	.8
G 3	Fertilizer for Oats & Topdress	6.	6	0	"	"	.8	..	.2	.6
G 4	Potato Phosphate	2.	13	0	"	"	.3	..	.7	.8
G 5	Soluble Corn & Gen. Crops Man.	2.5	10	0	No	"	.5	..	.5	.6
J 5	Soluble Potato Manure	4.3	10	1	Yes	"	.5	.7	.4	.6
	F. S. Royster Guano Co.									
J 6	Cuckoo Crop Grower	.8	8	0	Yes	Inferior	..	.5	.5	.9
J 7	Curfew Ammoniated Superphos.	3.3	8	0	"	Passed	..	.5	.5	.9
J 8	Defender Fertilizer	3.3	8	1	No	"	..	.4	.6	.8
J 9	Drillwell Phosphate	2.5	8	1	Yes	Inferior	..	.3	.7	.8
J 14	Goodwill Ammo. Superphos.	4.1	8	0	"	Passed	..	.5	.5	.9
J 13	Innovation Ammo. Superphos.	2.5	8	0	"	"	..	.6	.4	.9
J 10	Log Cabin Guano	4.1	8	1	"	"	..	.4	.6	.8
J 11	Logical Compound	1.7	8	1	"	Inferior	..	.2	.8	.9
J 12	Penguin Ammo. Superphosphate	1.7	10	0	"	Passed	..	.4	.6	.9
	J. W. Sanborn									
L 8	Prof. Sanborn's Chemical Fertilizer for Grass and Grain	4.9	8	0	No	Passed	.4	.1	.5	.7
J 2	Prof. Sanborn's Chemical Fertilizer for Use in Hill and Drill	2.5	8	0	"	"	..	.1	.9	.7
J 1	Prof. Sanborn's Chemical Fertilizer for Potatoes and Corn	3.3	8	0	"	"	..	.1	.9	.7
	Sanderson Fertilizer and Chemical Co.									
G 6	Atlantic Coast Bone, Fish and Potash, 1916	1.6	9	1	Yes	Passed	..	..	1.0	.9
G 7	Corn Superphosphate, 1916	1.6	10	1	"	"	..	..	1.0	.9
G 8	Potato Manure, 1916	2.1	8	1	"	"	..	.1	.9	.8
	Virginia-Carolina Chemical Co.									
D 15	Ammo. Bone Phos. for All Crops	1.7	10	0	Yes	Passed	..	.1	.9	.8
G 9	High Gr. Corn and Veg. Comp.	2.5	8	1	"	"	.3	..	.7	.8
D 16	Owl Brand Potato Fertilizer	1.7	8	1	"	"	..	.2	.8	.8
E 1	Plow Brand Fertilizer	.8	8	1	"	"	..	.3	.7	.9
K 14	Twentieth Century Potato Manure with 2 Percent Potash	4.1	8	2	"	"	.3	.1	.6	.8

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VI. CONCERNING TILLAGE

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INTRODUCTION

A decade ago eleven pages of print were used in bulletin 123 to set forth "The Moisture Relations of the Soil." A single page was devoted to a brief discussion of irrigation and drainage while ten pages were given over to the consideration of tillage, including a discussion of the conservation of soil moisture, of the effectiveness and nature of capillary water, of plowing, harrowing and intertillage. Three years ago in bulletin 173 the few words which were presented in bulletin 123 were expanded into a complete article on drainage. Two years ago the half page given over to the discussion of irrigation was expanded into a twenty page article in bulletin 182. And now, in view of the fact that bulletin 123 has long been out of print, the time seems ripe again to discuss in the annual fertilizer bulletin the general subject of tillage and in a somewhat more ample fashion.

Any adequate presentation of the subject of tillage methods naturally deals with why and how, with when and what, but more especially with why and how. Hence it is that this article is divided into two chapters. The first deals with objects and results, with fundamental principles; the latter with agencies, that is to say tillage machinery. In the first portion recourse has been had on pages 55 to 62 to an article issued in 1909 in the first annual report of the State Commissioner of Agriculture, now out of print. This article, entitled "The Philosophy of Tillage," was the product of one of the writers of this present bulletin and hence can be properly lifted and reprinted.

Webster states that tillage is "the operation, practice or art of tilling or improving land for agricultural purposes." The use of mechanical agitation of the soil to aid in crop production was the first step taken by our primordial ancestors in their abandonment of hunting and fishing as means of livelihood. Today tillage is first among the factors affecting crop growth which are not inherent properties of the soil. The difference between no crop and a successful crop often can be traced to the adequacy or inadequacy of tillage operations. Soil fertility, soil moisture, soil organic matter and soil structure are the foundation of crop growth, but tillage is the tool with which this foundation is made true and effective if properly done or caused to crumble if but poorly done.

The art and practice of agriculture have risen, flourished and waned many times in the history of the human race. Just how important a part tillage or its lack played in these early fluctuations it is difficult to say. It would seem as if the Mesopotamian husbandmen, to whose inventive genius, skill and patience may be ascribed the wonderful irrigation systems which thousands of years ago made the barren valleys of the Tigris and Euphrates blossom as the rose, or the prehistoric farmers who built and watered the marvelous terraces on steep Peruvian hillsides, would have known how beneficial is the stirring of the soil; but if they did they have left no records as to their tillage methods.

Vergil sings the praises of tillage:

"Much more advantage to the swain it yields
To use the rake than harrow sterile fields;
Nor golden Ceres from the lofty skies
Shall view his labor with regardless eyes.
And who, athwart the furrows plows the plain
Then breaks the clods obliquely o'er again,
Turning his team, and by a frequent toil
To obedience brings a disobedient soil."

A lack of adequate equipment and of a clear knowledge as to the relationships between soil culture and crop growth hindered for many centuries the development of a successful tillage practice. Jethro Tull has been considered the father of modern tillage practice. In his day, manure was supposed to pulverize the soil rather than to supply plant food. He argued that since tillage also pulverized the soil it could take the place of manure. He invented a drill and so improved the plows and cultivators then in use as to secure more thorough crop intertillage. He advocated intertillage of cereals as well as of potatoes, root crops, etc.

1. OBJECTS AND RESULTS

It is well known nowadays that tillage is a most important factor in plant growth. It is employed—

1. To modify the structure of the soil, with a view of securing a fine crumb structure without clod or separate grains; an ideal easier appreciated in the abstract than secured in practice, for the reason that the moisture and humus content of a soil are the determining factors in the matter and they are not always at an optimum.
2. To cover stubble and rubbish; more easily done today with our modern plows than formerly when forked sticks were used.
3. To incorporate manure and fertilizer with the soil.
4. To deposit the seed under a covering of soil.

5. To leave the surface smooth for subsequent operations.
6. To incorporate organic matter with the soil.
7. To control the water content of the soil, and to lessen evaporation.
8. To develop and maintain a large effective depth of soil, thus promoting full root development.
9. To aerate the soil.
10. To promote the growth of favorable bacteria.
11. To destroy weeds.
12. To reduce destructive water and wind erosion.
13. To destroy insect pests.
14. To economize seed.

Every one of these fourteen functions of tillage bears a vital relation to crop production; yet most farmers forget twelve and think of but two—namely:

The fitting of the soil; and the combat with the weeds.

SOIL MOISTURE CONTROL

The functions of soil moisture in crop growth are not always well appreciated. Water functions in tillage operations as a lubricant. It occurs as a thin film around the individual soil particles. When the soil is stirred by a tillage tool its particles slip over each other or separate along the line of this film. If the film becomes too thick or, in more common parlance, if the soil becomes too wet, the soil particles move individually and not as a unit or collectively, and they slide into place because of the pressure of the tillage implement. The action of the tool under such circumstances is like that of the trowel on mortar, and the result is approximately that which follows the process of trowelling. On the other hand when the water dries out of the soil the individual soil grains become closely packed together and present a smooth hard surface, resembling that of a brick. Nothing but the slow action of frost and other natural phenomena can loosen the soil after it has become thus puddled and packed as a result of being worked when too wet. The writer once saw a field which had been plowed in the spring when it was too wet and had been disced and harrowed nine times; yet it was still in poor and lumpy condition, the clods being brick-like and of brick size. Yet this same field in other years had been prepared for planting by three workings, twice with the disc and once with the harrow, simply because soil moisture conditions were better. The finer silts, heavy loams and clays are injured most when thus mishandled. The lighter sands and sandy soils do not suffer greatly because they lack a sufficient number of fine particles to bind them together when worked in an overwet condition.

If, on the other hand, the soil is plowed when dry and baked, the plow or other tillage implement tends at first to break the earth into large masses or clods. The soil particles are held together by the cementing power of the salts of the soil solution which were deposited as the water evaporated as well as by the binding power of the soil colloids, by the adhesion of the soil particles and the small film of water still in the soil, and by the cohesive attraction of the individual soil particles one for another, an attraction which is much more strongly exerted between fine soil particles than between coarse ones. The net result of the action of these binding agencies is so to consolidate the soil that it takes an enormous amount of power to break it up and loosen it. Anyone who has tried to plow an over-dry land thoroughly appreciates this fact. The soil holds tenaciously until it breaks into large masses, or, if the power is applied with a crushing action, the clods tend to crumble into a powdery, separate grain condition and the soil puddles with the first rain.

How can one tell when the moisture content of the soil is such as to favor success in tillage operations? By observation, by testing the soil with the hand. When it can be pressed into a mass that retains its shape upon releasing the fingers, yet can be crumbled again by pressure from one side, it is not too wet to work. This optimum water content often does not exist with heavy clay soils for more than a few days at a time. If considerable areas are to be broken up, either a large force of men, horses and equipment must be available, or else a greater or less portion must be worked when either too wet or too dry. This situation may be met in either of two ways. The heavier clays may be kept in meadow or pasture for as long a time as possible in order to avoid many workings; or they may be fall plowed when the moisture content is as nearly ideal as may be and then in the spring, when again in the optimum condition, they may be harrowed and otherwise fitted, thus handling a much larger area than would be possible if they were plowed solely in the spring.

The first working of the soil in the spring is a most important one. If some tool is used that covers a wide strip and passes but once in a place, the surface may be loosened and crumbled sufficiently to prevent it from baking into clods. Such a procedure tends to check the evaporation of soil moisture and to keep the soil in proper moisture condition for a longer period of time. Then the field may be harrowed in final preparation for the seed, and a seedbed of fine tilth may be secured.

Where spring plowing of corn or grain stubble is needed, soil moisture may be conserved and the plowing period prolonged if the entire field is gone over with a disc harrow. This serves to loosen the surface enough to check evaporation. Then, if plowed and promptly reharrowed, a good seed bed should be secured.

Eastern farmers often fail to appreciate the importance of conserving the water supply of the soil. The growing seasons of 1913, 1914 and 1915 were relatively dry and then if ever tillage operations to save soil moisture were needed. Good crops were secured when the opportunity was embraced to conserve moisture and poor crops on nearby farms where tillage operations were ill done or not done at all. Fall plowing wherever possible; early spring plowing as soon as the soil reaches its optimum water content; harrowing promptly in order to form a mulch and to save all the moisture possible; and intertillage after each rain to restore the surface mulch; these were the cultural practices which ensured good crops. Late spring plowing; harrowing delayed until the surface soil was baked; and entire neglect to intertill the crops after rains; these were the cultural methods which ensured poor crops.

Nature is usually kind to the Eastern farmer. She seldom omits to supply him with enough rain to grow a fair crop, if he helps her by saving what her bounty gives. However, many farmers fail to make the most of their opportunities since complete crop failure rarely follows even extreme neglect. Good crops are often secured in sections like the semiarid West where the annual rainfall amounts only to 15 to 20 inches—which is much less than half of that with which we are blessed. The dry-land farmer plows deep, maintains a dust mulch over his soil to save moisture, and does everything in his power to ensure successful crop growth. The same energy and forethought applied in average eastern farming operations would greatly increase crop yields.

WEED CONTROL

Weeds consume space, plant food and moisture which belong to the cultivated crops. The older they grow the more serious are the losses which they cause. Yet some farmers seem to act as if they thought it was unmanly to destroy a weed until it has gained its growth and become a foeman worthy of their steel—in fact sometimes superior to it. A weed, like any other plant, requires a root system and foliage in order to live. If either is removed the weed dies. It is a difficult matter as a rule to kill a full growth weed, but it is a simple matter to stir the soil and sever the root connection of small weeds which have just sprouted. It can be done in a wholesale and effective manner with a harrow or weeder; but if a heavy rain immediately follows, the root systems of the weeds may become reestablished. In such a case the harrow should be used as soon as the ground dries. Two such harrowings should eliminate practically every weed.

After weeds such as quack or witch grass, Canada thistle, wild morning glory and bindweed have established themselves, their vulnerable point is above ground. If the growth of stem and leaf is inhibited, the roots will starve and ultimately die. A thorough stirring with a tool that will cut some leaves and bury the rest is most effective to this end. The disc harrow or the sulky cultivator work well when the weeds are well developed; the spring tooth and smoothing harrows when they are just renewing their surface growth.

Weeds are thought to be a bane; but really they are often a blessing, in that they tend to stir the farmer to stir the soil. In so far as the presence of weeds leads to better tillage, they are a help rather than a hindrance. For example, if the smoothing harrow is used on a corn field a week after planting it is most effective in killing weeds; but is equally effective in renewing a surface mulch which will conserve moisture, and in a dry season the moisture thus saved may prove a large factor in the growth of a good corn crop.

"THE PHILOSOPHY OF TILLAGE

"Doubtless had it not been for the little episode detailed in one of the earlier chapters of Genesis in which our primal mother and the serpent took part, there might have been no need for this article on tillage. But since by the sweat of man's brow one's bread must be earned, the ground must be tilled before it yields its harvest. Inasmuch as there is not commonly held a full, all-round conception of the manysidedness of tillage operations; inasmuch as there is a tendency upon the part of too many farmers to look to artificial plant food rather than to developed plant food for the growing of crops; inasmuch as the ease with which commercial fertilizers may be bought and the inadequacy of farm labor tend to augment the neglect of tillage operations; on all these accounts it seems worth while to set forth in some detail the service or rather the services performed thereby to the end that they may be the better done.

"The commercial fertilizer does but one thing. It furnishes available plant food for plant needs. If it is a good fertilizer, if it has been wisely chosen following the suggestions made in other portions of this bulletin, it may do that one thing very well; but it is only one thing. Tillage, however, as has just been said, has many sides. It does manifold things, things chemical, physical, biological. Tillage operations increase the fertility of the soil in that they make more available the plant food already present. Tillage modifies soil texture in that it makes more fine the soil particles. Tillage by modifying texture and increasing porosity enables the bacterial life of the soil to multiply. Tillage in conserving of soil moisture more perhaps than any other one thing promotes crop growth. And, finally, it discourages the growth of weeds. That tillage in some degree does what a commercial fertilizer does has not always been recognized. That fining the soil increases the surface exposure of soil particles, thus leading to their more ready solution which means increased plant food availability and augmented crop growth, all these have been appreciated for years; but that tillage has five talents where the fertilizer has but one has not been generally understood.

"Professor King, in his article on 'Tillage, its Practice and Principles,' in the Cyclopedia of American Agriculture, (Bailey) volume 1, page 379, develops in succinct form the essential and fundamental propositions relating to tillage. Quoting these from his article in very slightly modified form it may be said that tillage:

1. Secures a thorough surface uniformity of the field so that an equally vigorous growth may take place over the entire area.

2. Develops and maintains a large effective depth of soil, so that there shall be ample living room, an extensive feeding surface and large storage capacity for moisture and available plant food materials.

3. Increases the humus of the soil through a deep and extensive incorporation of organic matter, so that there may be a strong growth of soil microorganisms and the maintenance of a high content of water-soluble plant food materials.

4. Improves the tilth of the soil so that the roots may ramble and soil organisms wander readily and widely thus placing themselves in contact with ample supplies of food materials.

5. Controls the amount, regulates the movement, and determines the availability of soil moisture, so that there shall never be an excess or a deficiency of this indispensable carrier of food materials to and through the plant.

6. Determines the amount, movement and availability of water-soluble plant food materials present in the soil, so that growth may be both rapid, normal and continuous to the end of the season.

7. Converts the entire root zone of the soil into a commodious, sanitary living and feeding place, perfectly adapted to the needs of the roots of the crop and to the soil organisms, one which is adequately drained, perfectly ventilated and sufficiently warm.

8. Reduces the waste of plant food materials through the destruction of weeds and the prevention of their growth and through the prevention of surface washings and drifting by winds.

"A few words concerning each of these several propositions.

a. THE SECURANCE OF SURFACE UNIFORMITY

"In a region of uneven topography such as obtains in New England, it is quite impossible always to make an absolutely even and uniform seed bed; but as close an approximation to this condition as is practicable is worth while in the interests of a full stand. Few farmers appreciate the loss arising from the empty places in an uneven, irregular, poorly planted piece. All the costs except that of harvest are essentially the same whether the stand is an even or an uneven one. It costs as much to fit, to plant, to intertill, to fertilize an uneven stand of corn as one that has come well. Better seed, more adequate tillage, well chosen fertilizers, good under-drainage, anything which tends to promote evenness of stand is apt to be worth while.

"The means for the securance of this surface uniformity naturally varies with different pieces. On the newer lands the removal of stumps, stones, etc., necessarily precedes breaking, pulverizing, and smoothing. Many Vermont fields would grow larger crops of more even stand were they well under-drained. Some of them would be improved by irrigation. In some sections, but not to any extent in New England, attention must be paid to the prevention of surface wash and of wind drifting.

"All bits of refuse, etc., which would interfere with crop growth, should be turned under to the end that high degree of tilth should be obtained which will enable a uniform depth of planting; such, moreover, as will secure conditions favoring an adequate moisture content and a plentiful supply of heat, a high degree of porosity, in short, that condition of loamy mellowness which is well understood to be best adapted to the germination of seeds, to the rapid forcing of a crop, and to the procurement of the highest productive capacity.

b. THE DEVELOPMENT AND MAINTENANCE OF A DEEP SEEDBED

"The seed is alive. It needs a place to live in just as much as the human being needs a house, or the horse and cow a stable. This mansion must be ample in size, sufficient to allow it to stretch itself. There must needs be a living room, a dining room, a kitchen and pantry in the soil for each seed, not to speak of a moisture storage which may be likened to the well. All these are furnished if the seedbed be deep. The living room is the place where the seed lives, establishes its roots, starts its stalk. Its dining room is the place where it gathers those mineral forms of plant food and nitrates which enable it, together with the carbonic acid gas obtained from the air, to grow to maturity. The kitchen is the work room in which the microorganisms prepare and transmute the plant food stored in the pantry, getting it into such condition that it may be absorbed by the plant roots in their dining room banquet. The cistern or well is the storage of water whence the plant drinks. Possibly the reader may think these similes are forced: and yet the plant lives, breathes, eats, drinks, moves, and needs conditions and environment wherein to perform these functions as much as does animal creation. A neglected, ill-fed, poorly housed animal suffers; and so does a neglected, ill-fed plant in a poorly-tilled soil. If through inadequate tillage operations, an inferior dwelling house is afforded the crop, one into which it is difficult for it to send its roots, from which it is impossible to gain adequate moisture or food, it does not thrive and crop growth suffers.

C. THE INCREMENT OF THE HUMUS CONTENT

"Bulletin 135 discusses humus at considerable length. It was stated therein that humus benefits the soil by supplying nitrogen directly; by supplying phosphoric acid, potash and lime indirectly; by augmenting the water-holding capacity of the soil; by increasing its warmth and bettering its texture; and by affording protection for microorganic growth. The serious effects of a shortened humus supply upon the individual farm and upon the well-being of mankind as a whole were pointed out, as well as the effects of current agricultural methods upon its maintenance. It was pointed out in this bulletin that the continued growth of tilled crops, the employment of rotation which does not include therein the growth of grasses and legumes, fallowing, deforestation, forest fires, and the continued use of commercial fertilizers, all tend towards the exhaustion of humus supply. The same is augmented, however, by a crop rotation which includes grass or legumes, by the use of farm manures, and by the practice of green manuring.

"The incorporation of organic matter into the soil where it may be transformed into humus is one of the most important functions of tillage. It is one of the main sources, sometimes the only source, whence nitrogen is conveyed to crop growth. This ingredient is the most expensive form of plant food purchased in commercial fertilizers. Moreover, as was pointed out in bulletin 130 at great length, it is the most evanescent of plant foods. Nature's methods and man's prodigality seem banded in a conspiracy to denude the soil as rapidly as may be of this valuable plant nutrient. It is, moreover, sold from the farm in considerable quantities in the form of milk, live stock, grain and in other ways. On this account it is vitally necessary that farmers appreciate the relationship of tillage operations to the incorporation of these nitrogen-containing materials into the soil.

d. THE BETTERMENT OF TILTH

"The person who stays at home all his life and never travels may be a very good man but he is not apt to be a broad one. Travel is one of the best means of education, of enlarging one's power for service. Similarly with the plant. A crop which is bound tightly in a poorly tilled soil so that its roots cannot spread widely cannot grow to that full stature which it should and might assume if its roots had a chance. An animal may move from place to place and seek food; but plants can only make use of the food which their roots can reach. The writer has sometimes likened this phase of tillage operations to a railroad ticket in that it permits the roots to travel.

"The relationship of the soil organisms to crop growth was discussed at length in bulletin 130. It is now thoroughly well understood that the soil is alive with bacteria, which functionate in crop growth and in the solution of plant food as well, in the preparation of the nitrogenous forms for crop service. Some of these organisms are helpful, some are hurtful; and the helpful ones are helped and the hurtful ones are hurt, speaking broadly, by adequate tillage.

e. THE CONTROL OF THE MOISTURE CONTENT

"Everyone appreciates the effect of a droughty or of an over-wet season upon crop growth. Either an excess or a deficiency of water spells disaster. In a country which is dependent for its soil water supply upon rainfall, tillage cannot absolutely control the water content of the soil; but it can go a good ways towards it. In central California where the soil depth is almost limitless, of great water holding capacity and where the seasons are divided into the wet and the dry, the writer has seen luxuriant vegetation in absolutely dry weather, after four months have elapsed without a rain drop. The moisture in the soil was kept from undue evaporation from the surface by the frequent intertillage of the crop. Under eastern conditions this matter may be controlled to some extent by proper attention to intertillage. In this connection see the matter on pages 52 to 54.

f. THE PROMOTION OF PLANT FOOD AVAILABILITY

"Neither plant nor animal is capable of making use of food, except in solution. It enters the animal's system through the intestinal wall and passes into the lymphatics and the blood. It enters the plant system through the wall of the root and in gaseous form through the stomata or breathing pores of the leaves. The chemistry and physiology of the construction within the animal and the plant structures of the complicated molecules which compose them is not a matter with which we are interested in this particular article; but the particular point to be made here is that the plant food must be made soluble before it is of the slightest service. The agencies of solution are many. The moisture of the soil, the microorganic life of the soil, the action of earthworms, soil acids, doubtless the acid exudates from plant roots, the effect of weathering; all these and doubtless others, perhaps some of which we have no notion, have relation to this important matter. But one point in particular is very clear, namely, that in proportion as the particles are made more fine, they present a larger surface area to the action of these various agencies and hence more plant food can be dissolved thereby in a given time. The writer has many times in presenting this matter orally, made use of the following illustration: Two spoonfuls of sugar contain the same amount of sugar as do two lumps; but if the spoonfuls be stirred in one cup of coffee and the two lumps in another, the two spoonfuls will be dissolved much more easily and quickly than will the two lumps, simply because they offer a larger surface area to the dissolving fluid than do the lumps. Similarly with a soil. A fine soil is more fertile than a coarse one. The fining of soil by tillage is essentially the same thing as the furnishment of available plant food, in that it makes a larger proportion of the plant food naturally present available to crop growth.

g. THE PROMOTION OF SOIL HEALTHFULNESS

"It is a comparatively new notion that soils may become sick. Yet it is quite certain that this is the case. Soils sometimes become dyspeptic as it were; sufficiently acid in their character as to cause inferior forms of plant growth to thrive rather than superior ones. The causes for soil acidity are many. It may be due either to a lack of or to an excess of humus; to the over-usage of commercial fertilizers; to the leaching of lime from porous soils; or to other reasons; but we know that tillage to some degree and under some circumstances, is apt to better these conditions. Lime, however, is a more certain remedy.

"One school of soil investigators has, of late, broached the idea that soils get into an unsanitary condition through the accumulation of toxic or poisonous excretions; certain more or less unknown organic substances which become harmful to the further growth of the sort of plant producing them. They claim that a certain portion of the benefits which are derived from thorough tillage and intertillage should be ascribed to the aeration thus produced and to its effect upon these toxic bodies. Whether this claim is or is not entirely borne out in fact, it is certainly true that a soil which is poorly tilled is not one in which crops thrive. Such tillage operations as tend to promote adequate soil drainage, soil ventilation, and the entry of a sufficient amount of heat aid in the bringing about of a more healthful condition of the soil and in the promotion of crop growth.

h. THE REDUCTION OF WASTE DUE TO WEED GROWTH AND EROSION

"The common conception which farmers hold as to the underlying reason for hoeing crops, of running the horse hoe, the weeder, the cultivator, is that it is done in order to kill weeds. The weed killing proposition is important but subsidiary. A much more vital matter is the saving of moisture to the crop by the breaking up of the capillary tubes, the lessening of evaporation, and by the removal of a class of growth which is an avid user of water and of plant food. (In this connection see the matter on pages 54 and 55).

"The relationship of tillage operations to the prevention of erosion was discussed at considerable length in bulletin 135. It is stated therein that while this proposition is not an important one under New England conditions, in certain sections the relation of tillage operations and of tillage instruments to the control of this situation is important. A deep soil which provides a large chance for rain storage and one in which deep rooting crops like clovers may be grown; a soil which is bound together with a dense growth of grass roots; a soil which is well stored with humus by the use of farm manures, the practice of green manuring, and of grass growing; all these are conditions which tend to lessen the extent of devastation by surface washing or wind sweeping. So long as Vermont remains primarily a dairying region, we may not fear that the fate of Palestine or of Mississippi will be hers. Thanks to the cow, to grass, and to clover, her hillsides will remain green for generations."

2. TILLAGE MACHINERY

Tillage machinery is roughly divided into two classes, namely, tools that move the soil either by its inversion or by stirring—and these are the more common sort—and those that compact the soil. Among the former are included plows, harrows, planters, cultivators, weeders; among the latter, rollers and plank clod crushers.

TILLAGE TOOLS WHICH INVERT OR STIR THE SOIL

THE PLOW

The earliest records of agriculture mention the plow. In its primitive form it was simply a natural fork from a tree drawn by women, or later, by oxen. Then iron strips were fastened over the point in order to check the rapid wear on the wood (Samuel 13: 20). The action of these early plows was similar to that of the modern cultivator teeth. Improvements followed in due time which increased the penetration and lifting power of the plow. At first the furrow was pushed to one side, much as snow is pushed aside by an A plow. In 1720 Foljambe of Yorkshire, England, secured a patent on a plow that had "vertical and horizontal wedges combined in a moldboard and connected by a curved line so that the furrow slice was first raised a little and gradually inverted clear of the space in which it lay." The form of the moldboard was modified still more, especially by Small and Wilkie of Scotland and by Thomas Jefferson. In 1785 an Englishman named Ransome secured a patent for making plows of cast iron and, eighteen years later, he patented the method of case hardening or chilling shares. Among those whose names are writ large in the annals of plow history in the United States may be mentioned those of Wood, Stevens, Nourse, Mears, Knox, Deere, Lane and Oliver; and it is of interest to note in this honorable company the name of one of Vermont's war governors, who lived to a ripe old age and who has but recently passed from among us—the late Ex-Governor Frederick Holbrook of Brattleboro.

The plow now has reached a high stage of development. Special forms of moldboard and share have been adapted to every conceivable condition of soil. "The modern plow has wrested an abundance from the soil. Animals harnessed to it have freed the peasant from the heaviest of all tasks and given him leisure to advance in knowledge. The world now rests in confident anticipation of the farm's certain surplus. Civilization and the plow have gone together, and whatever advancement of humankind we may look forward to will surely be paralleled by perfection now unattained in that noblest of instruments. Fitting it is that the United States Government should place the plow prominently on the great seal of the Department of Agriculture" (12).

The types of moldboards found today are best illustrated by the common walking plow. Three types are recognized. There is the breaker or sod plow with its long, slow moldboard twist, used to turn an unbroken sod furrow. There is, at the other extreme, the stubble or old land plow, its moldboard turning at a very abrupt angle, throwing the furrow sharply to one side and crumbling to the *n*th degree. And, midway between these two types, there is the general purpose plow which does not pulverize old land as much as does the stubble type, but can be used to fair advantage on all but the toughest sods. The general purpose plow serves a good purpose on most Vermont soils, the sod plow does best on heavy clay soils, and the

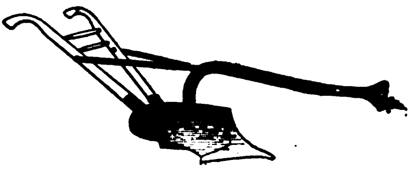

FIG. 1. A two-horse turning plow, a type used throughout the corn-belt states.[1]

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[1] For this and succeeding cuts, reproductions of some of those used in Federal Department Bulletin 320, the Station is indebted to the courtesy of the United States Department of Agriculture.

stubble plow is used most frequently on the lighter sandy soils, putting the ground in such a condition that it usually requires very little further treatment before planting. It sometimes does better work on heavy clays than the sod plow, but its draft increases out of proportion to the added work done, and hence it is not to be recommended. Furthermore it presses so firmly against the furrow in twisting it to one side that if a soil is over wet the moldboard slickens and puddles the surface more than do the sod and general purpose types.

More of the plows in use today are walking plows of one or the other of three types. The back furrows and dead furrows it causes are undesirable, particularly on land that is well drained, but they often are a distinct advantage on level and poorly drained land since they act as shallow surfaces ditches.

The walking plow is disadvantaged on rolling land in that it does not turn a furrow uphill. This necessitates plowing up and down the slope, which requires the expenditure of more power. The hillside plow overcomes this obstacle. Its moldboard and share are hung by a swivel to the plowbeam and can be locked so as to turn a furrow either to the right or to the left. Because of this double construction of share and moldboard a rougher furrow is turned than when the walking plow is used; but the effectiveness of its pulverizing action is not lessened, and we must remember that that is what a plow is used for—to pulverize the soil. Where drainage conditions are good, level fields have followed its use. Indeed it is being used largely on irrigated farms in the West and is becoming increasingly popular.

The reversible sulky plow is really two separate plows in one, a right hand and a left hand, so hung on a frame that one plow can be used while travelling in one direction while the other is held free from the land and vice versa. Any moldboard type can be used. It works better than the hillside plow on level land.

Sulky plows, either one or two bottom, are not common in Vermont. The one-way sulky turns a steadier furrow than the walking plow, but its cost is relatively

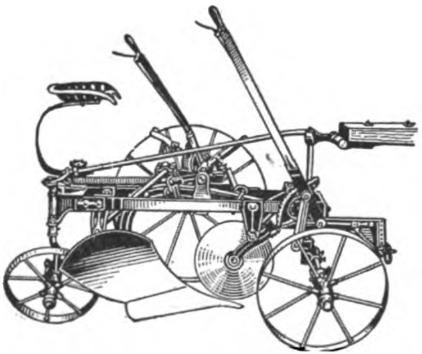

FIG. 2. A sulky plow (for either two or three horses), used in the corn-belt states.

high. The two bottom sulky requires four or five horses and is adapted to use on our large level fields or valley farms. Clearly the field of the two bottom sulky is not large in a state topographically irregular as is Vermont. The gang plow with two or more shares is a development of the sulky form. These are drawn mostly by traction engines. A diminutive gang of three bottoms, each capable of turning an eight-inch furrow to a depth of three to four inches has been developed for shallow cultivation in orchard work. It can be handled by two horses.

The subsoil plow consists of a long, thin shin or upright with a narrow share and frame but no moldboard. It is used to follow in the furrow of a walking or other common plow and raises and loosens the soil to a depth of eight to twelve inches below the furrow. Where the subsoil is dense and hard this tends to improve aeration, drainage and general root development. However the moisture conditions of the soil must be made right if one is to succeed in the use of the subsoil plows. If one waits in the spring until the subsoil is dry enough to make subsoiling safe, the surface soil will be usually too dry to be plowed to advantage and, furthermore, will have lost much of the moisture that is needed for crop growth. Then, again, loosening the subsoil in the late spring tends to cause the formation of large masses that may serve to impede the capillary movement of soil water. Under such circumstances crops are likely to suffer for lack of moisture. If, however, the soil has time to readjust itself after the subsoiling has been done, and if the soil masses can again crumble before the crop is planted, it may be worth while to practise subsoiling. In such a case it should be done in the fall so that the larger clods may become disintegrated through the action of winter's frosts. The subsoil plow has never been and seems likely never to be widely popular in these regions. Subsoiling is not a practice which as a rule is adapted to Vermont conditions. It is primarily a practice suited to semiarid and not to humid lands.

The disc plow, either as a single or double disc sulky, has enjoyed only a limited vogue in this section.

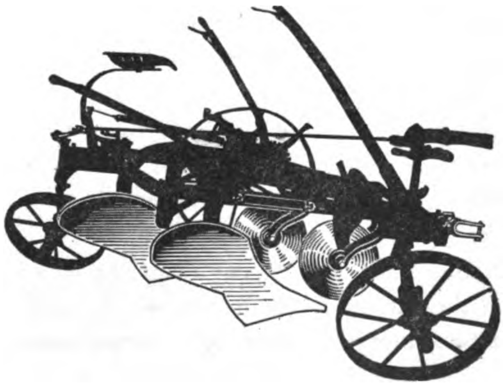

FIG. 3. A gang plow (for four or five horses), used in the corn-belt states for breaking land.

The diameter of the disc is usually from 22 to 26 inches, and it turns a furrow which is from 6 to 10 inches wide. This form of plow will cut through and break up a dry soil better than does a moldboard plow, but a considerable weight is needed in order to keep the plow in the ground. A sticky soil which will not scour a moldboard plow can be turned successfully with a disc. Except for dry and sticky soils the moldboard plow is to be preferred, for it handles easier and requires slightly less draft.

The deep tilling machine is a modification of the disc plow, consisting of two discs set so that one travels in the bottom of the furrow made by the other. In this way a furrow 12 inches wide and 15 to 18 inches deep is turned, using four or five horses. This plow does not stir the soil quite as deeply as does the subsoil plow, but it crumbles it in a much more satisfactory manner. It is said that considering the work done its draft is not excessive (9).

PLOW ACCESSORIES AND THEIR ADJUSTMENTS

The coulter or knife helps in cutting the landside of the furrow. The fin coulter, fastened to the share and extending upwards free, works well on sod lands but cannot be adjusted to the conditions met in different soils. The more common form is the so-called standing coulter, consisting of a knife fastened to the beam and extending down towards the point of the share. Its position affects both the draft and the operation of the plow. It should be so placed that its point is located about one and one-half inches back of and a half inch above the point of the share, and it should slope back so that when in use it runs under the turning furrow instead of dragging through in a perpendicular position. When it is thus set the share lifts the soil slightly before it is cut by the coulter. If the coulter is set too far back, the share tends to tear the furrow from the landside before it is cut, thus increasing the draft. Its vertical position is also important since both the width of furrow and the "running" of the plow are thus affected. In general the coulter should cut as nearly as possible a vertical edge at the landside, at a point about a half inch to the landside of the plowpoint. If a plow scours poorly and the coulter is set so as to cut about one inch into the land, the added width of the furrow by its greater weight may cause the moldboard to scour satisfactorily. If the coulter is set so that it is twisted either towards or away from the land, it tends to act as a rudder and to cause the plow to climb and swing from side to side, regardless of the adjustment of the clevis. It can be brought into line by wedging the shank of the coulter against the beam.

The rolling coulter consists of a flat thin disc set to cut in the position usually occupied by the standing coulter. It may be placed on a rigid or on a swivel shank, the latter being preferable. It is thinner than the knife coulter, offers slightly less resistance to the soil and, being sharper, cuts with less draft. It rolls over trash instead of catching in it as does the standing coulter, and, being self-aligning, does not tend to run the plow out of line. On stony soil, however, it rides over the stone and thus tends to jump the plow from the ground.

Sanborn (21) states that the draft of a plow is increased by the use of any form of coulter, because the friction surface is increased. He holds that this increment fully offsets the advantage derived from cutting the furrow.

The jointer, a modification of the coulter, consists of a diminutive plow that turns a furrow one and a half to two inches deep on the edge of the regular furrow in such a way that when the main furrow is inverted the edge is turned out of sight. In plowing sod land which must needs be promptly prepared, the use of this device serves to cover all sod and aids in the formation of a mellow seedbed. It is a helpful adjunct in covering trash. Its adjustments are similar to those of the standing coulter.

The gage wheel is placed at the end of the plowbeam to assist in controlling the depth of the furrow. When rough and stony land is being plowed it throws the plow up and down enough to offset whatever advantages accrue from depth control. It is sometimes said to its detriment that depth of the furrow is apt to be adjusted entirely by means of the wheel instead of by the clevis—an undesirable result. However, the plow runs easier when the gage wheel is properly used and its draft is reduced.

A covering chain is of considerable help where tall rank weeds or cover crops are to be turned under. It consists of a short length of common chain fastened at one end to the furrow clevis of the evener and at the other end to the plowbeam just back of the coulter, with slack enough to allow the chain to drag on the ground.

ADJUSTMENTS OF THE PLOW

The ability to turn a smooth even furrow is determined quite largely by the proper adjustment of the line of draft between the source of power—the horse's shoulder—and the center of application—

the point in the plow around which the draft is equal on all sides. This center of draft in the plow varies with the depth and width of furrow, as well as with the nature and condition of the soil and the shape of the plow. "On stubble and general purpose plows it will be close to the shin (or front edge of the landside) and to the junction of share and moldboard. On plows designed for breaking tough sod at a shallow depth it will be closer to the point and the sole. Professor Gilmore, (formerly) of Cornell University, states that it is located behind the moldboard and two and one-half or three inches from the wall and sole of the furrow" (12). The hitch at the clevis can be adjusted either horizontally or vertically; but no matter where the hitch is the line of draft will tend to straighten, that is to say, to assume a straight line when the horses apply their power. Thus if the hitch has been made too far to the left side of the clevis on a right hand plow, the end of the beam will swing to the right in order to straighten the line of draft, and as a result the plow will "run away" from the land and cut a narrow furrow. To offset this tendency the plowman will have to "ride" the right handle. Similarly if the hitch at the clevis is too far to the right the plow will be swung into the land and take a wider furrow than it can turn while the plowman will be forced continually to "ride" the left handle. If the hitch is too low in the vertical adjustment on the clevis it will raise the end of the beam and the plow will not keep its depth. If too high at the clevis, the plow will "ride on its nose" and tend to plunge too deeply into the soil. When these adjustments are correct the plow will move straight ahead. Indeed, in a mellow soil it will keep its place without attention from the plowman, except when encountering a root, stone or other obstruction. In no way is a plowman's skill more clearly made manifest than in the manner in which he is able accurately to make these adjustments.

Another adjustment that affects the team more than it does the plow is caused by the straps which are provided at the rump for holding up the traces when the horse stands. If these are too short an angle is formed at this point and the horse pulls down on his back to no profit. Sanborn (21) found "the downward pull at this point to equal 50 pounds or one-third the pulling power of an average 1,200 to 1,500 pound horse—a third of the animal's power was being used to gall and annoy it instead of being applied to the work in hand."

The condition of the point and the cutting edge of the share also affect the service a plow can render. A worn or rounded point should be renewed; a dull share edge ground or replaced. When shares are heated and pounded thin on the edge, their former lines are not readily restored. It often happens that a reforged share, though sharp, affects the draft of the plow as unfavorably as before sharpening, for the reason that it has been warped out of line. A new plowshare when set on a straight board should touch at the point, at the heel or wing of the share, and at the heel of the landside; and at the center it should be an eighth of an inch above the board. This curvature is called the "suction" of the plow and tends to keep the point in the ground, and it should as far as possible be retained if the share is resharpened.

DRAFT OF PLOWS

Gould (14) in the Utica plow trials of the middle of the last century found that 55 percent of the draft of the plow was due to the work exerted in cutting of furrow slice, 35 percent to the friction of the plow against sole and furrow and only 10 percent to the work exerted in lifting and turning the furrow. Sanborn (21, 22) found that when the plow was so adjusted as to cut either wider, narrower, shallower or deeper than the normal adjustments of the plow contemplated an increase of from 15 to 20 percent in the draft per square inch of furrow ensued and that poorer plowing was accomplished.

Ocock (19) studied the relation of wet, of dry and of good soil conditions to draft when using different types of plow. The following tabular statement is drawn from his publication:

	Dry soil		Wet soil		Good condition	
Depth of furrow in inches	Total draft	Draft per sq. inch	Total draft	Draft per sq. inch	Total draft	Draft per sq. inch
FOURTEEN INCH TURF BOTTOM PLOW						
4	291	4.61	295	5.26	241	4.31
5	318	4.54	370	5.26	296	4.26
6	318	3.92	330	3.92	353	4.20
7	413	4.26	423	4.31	406	4.14
8	436	4.20	478	4.26	430	3.83
SIXTEEN INCH TURF BOTTOM PLOW						
4	331	5.18	303	4.68	298	4.68
5	331	4.14	341	4.29	360	4.50
6	481	5.01	433	4.51	418	4.36
7	510	4.55	485	4.66	468	4.17
8	571	4.46	523	4.09	518	4.04
FIFTEEN INCH STUBBLE AND TURF BOTTOM PLOW						
4	318	4.96	355	5.59	300	4.58
5	393	4.91	393	4.91	370	4.62
6	445	4.31	415	4.38	435	4.53
7	503	4.48	483	4.31	525	4.09
8	570	4.45	546	4.24	525	4.09
FOURTEEN INCH STUBBLE BOTTOM PLOW						
4	315	5.62	285	5.09	275	4.91
5	383	5.47	330	4.57	310	4.43
6	555	6.54	380	4.52	360	4.28
7	596	6.08	435	4.44	410	4.18
8	548	5.19	502	4.53	450	4.02

This table is typical of available draft data. Clearly total draft increases with depth and width of furrow, but draft per square inch cross section of furrow decreases as the depth of furrow increases. In other words a given volume of soil is moved more economically in a deep furrow than in a shallow furrow.

Much work yet remains to be done in testing the draft of plows and other tillage implements, but enough has been done to show the importance of proper adjustment. Since half of the power required to draw a plow is used in cutting the bottom and side of the furrow slice, obviously it is highly desirable that coulters and shares should be in prime condition and be properly adjusted.

CHOICE OF PLOW

When the furrow is inverted by the plow the entire furrow slice undergoes shearing strains that tend to crumble the mass. This action of the moldboard can be illustrated by taking the leaves of a book in one hand and bending them sharply to one side. The leaves are seen sliding past each other for the reason that they represent circles of unequal diameter. Those on the inside are curved around a much smaller circle than those on the outside. This same action takes place as the furrow is turned by the moldboard. The bottom of the furrow has to travel farther than the top and the entire mass tends to separate into aggregates of various sizes. The deeper the furrow the greater the internal strain developed, because there is a greater difference in the distance travelled between top and bottom of furrow. The stubble plow with its abrupt moldboard emphasizes this action, consequently it pulverizes the soil much more thoroughly than does the slow-turning sod plow. If a soil is too wet when this shearing action takes place the soil particles tend to slip past each other and pack into a dense puddled mass. It follows then that when it is necessary to plow a soil which is too wet it should be disturbed as little as possible. A shallow furrow turned with a sod plow meets this condition. If on the other hand the soil is too dry when plowed it is desirable to pulverize it as much as possible in order to prevent the formation of large clods. This may be done—if there is power enough available—by using a stubble moldboard and by plowing deep.

DISC HARROWS

The disc harrow is second only to the plow in tillage operations. It inverts and pulverizes the surface three or four inches of soil in the same way as the disc plow does to greater depths. Indeed sometimes no plowing whatever is necessary and the disc harrow is the first tool used in preparing the seedbed.

The full bladed disc has solid perfectly rounded edges. It is the best form of this implement for general purposes for the reason that it exerts a greater pulverizing action, cuts up trash better, and can be more easily sharpened than other forms. The disc is usually 16 inches in diameter. A disc of this size penetrates the soil easier than does one of a larger diameter, because it has a smaller bearing surface on the ground. Furthermore it turns over more times in travelling a given distance, thus tending to pulverize the soil more effectively. Eighteen and twenty-inch discs are less desirable, although they are more durable. However, if set at a sharp angle they can turn the soil deeper than the smaller discs and more successfully replace the plow. Sizes smaller than 16 inches do not afford sufficient space below the axle.

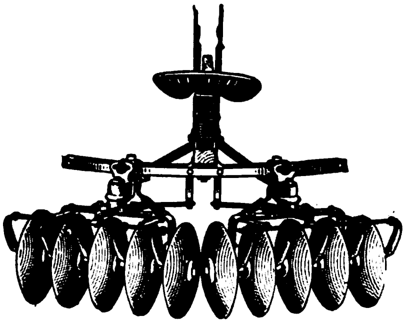

FIG. 4. A disc harrow, extensively used for seedbed preparation following plowing.

Three horses should be used on a twelve-blade disc harrow for the reason that the harrow cannot be set to do as effective work when only two are used unless the driver walks, as the extra weight causes greater penetration than the team can effectively cope with.

The cutaway disc is similar to the full bladed except that notches are cut out of the edge of the disc. Davidson (9) states that "the cutaway harrow is very deceiving in the amount of work it does. The blades sprinkle the soil over the surface in such a way that the unstirred soil beneath is hidden. This harrow has a decided advantage in cultivating and renovating old pastures. Where the full-bladed disc would cut the stubble up and destroy it, the cutaway will loosen the soil in such a way as to stimulate growth."

The spading disc harrow is a further development of the cutaway in which a series of curved blades are fastened in the form of a wheel. It has nothing to recommend it for general use except the fact that it can be used in wet ground when the full disc harrow would clog. It is a question whether or not it does more effective work than the cutaway and certainly it is somewhat more complicated in its construction.

In adjusting the disc harrow it is desirable to have a lever for each gang of discs so that they can be set at different angles whenever necessary. The tongue truck is also desirable for it does away with the necessity of lashing of the tongue on the horses' necks. Some farmers object to the tongue truck because the harrow is difficult to guide when travelling on the road and there is greater danger of getting the team tangled in the harrow when turning. A tongue fastened to the tongue truck will overcome these objections.

The double disc harrow is gaining in popularity wherever large fields occur and sufficient power is at hand. It consists essentially of two harrows in tandem. By setting one to throw each way the ground is worked twice and left in level condition. At least four horses are needed to do satisfactory work. The reduction in time in which one man can cover an acre when using this implement makes it a paying investment.

HARROWS

The first harrow was doubtless simply a tree limb; then short sticks were fastened to the limb in order to improve its action; and, later, the "A" drag was developed. There are two common types now in use—the spring-tooth and the spike-tooth or smoothing harrow.

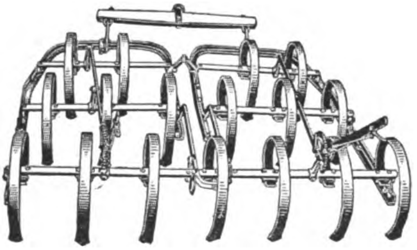

FIG. 5. A spring-tooth harrow, largely used for seedbed preparation following plowing.

The spring-tooth harrow is used in some cases for the first working of plowed land. It is less efficient than the disc harrow in proportion to the power required. It does not work well on sod land for the reason that it brings sod and trash to the surface. It is seldom used to follow the disc harrow since it leaves the soil surface in too uneven a condition. It loosens a compact soil and does a large amount of work. It does better work than the smoothing harrow on soil infested with quack grass roots, but is less effective than the disc, especially if the latter is weighted in order to hold it down into the soil.

The spike-tooth or smoothing harrow is used on practically all Vermont farms. It finishes the pulverization and leaves the soil surface in good condition for the seed. By setting the teeth so that they slope to the rear it can be used as a weeder after the crops are planted and as a means of rapidly establishing a soil mulch.

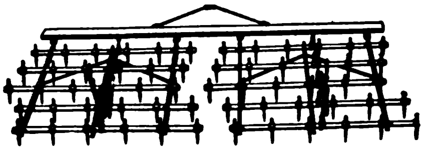

FIG. 6. A spike-tooth or smoothing harrow, in general use for seedbed preparation following plowing.

A harrow's teeth should be sharp and should number from six to nine for every foot of width. The more the teeth, the better the result of stirring of the soil. When they become dull they can be reversed.

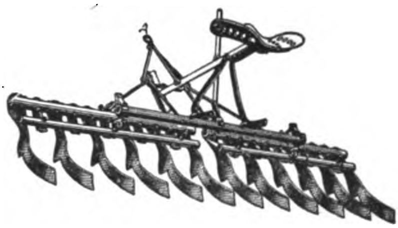

FIG. 7. An Acme harrow, an excellent pulverizer.

A sulky harrow with teeth resembling those of a cultivator is used quite frequently in harrowing up old land and in orchard cultivation. The teeth can be gaged for depth by levers. The combined weight of the implement and the rider so depresses the teeth that they tear up the soil very effectively.

PLANTERS

The action of the implements used in planting should not be overlooked. The grain drill with hoe furrow openers is quite an effective harrow; broadcast seeders possess a set of regular harrow teeth; and corn planters, potato planters and transplanters in a small way are of service.

CULTIVATORS

The harrow is of use chiefly as a means of reducing the soil masses and developing a fine seedbed. The cultivator is used primarily to destroy weeds and preserve a surface mulch. Some farmers use the cultivator to complete the preparation of the seedbed which has been but half finished when the crop was planted. This is not an economical procedure for the reason that the one horse cultivators which are commonly used cover very narrow strips. There are cases where regular harrows and other tillage implements can be used essentially as a cultivator immediately following planting with a view of killing weeds and maintaining a mulch rather than of pulverizing

SEVEN TYPES OF CULTIVATORS

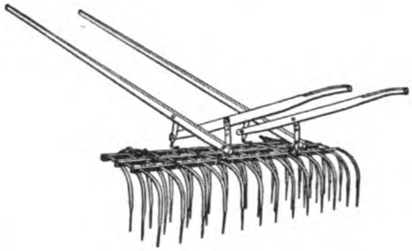

Fig. 8. A weeder, used in early cultivation.

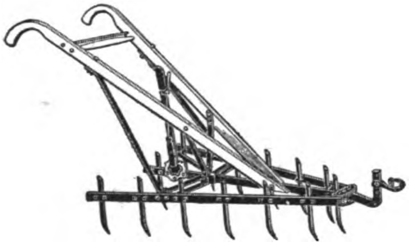

Fig. 9. A one-horse spike-tooth cultivator.

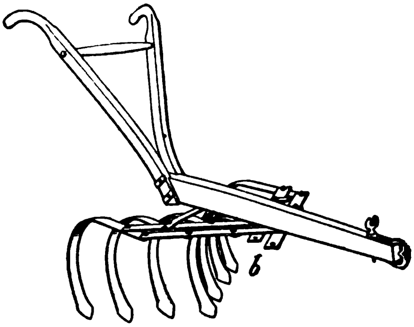

Fig. 10. A one-horse, spring-tooth cultivator for stone-free land.

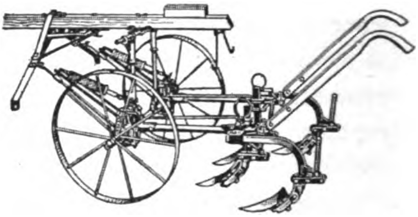

Fig. 11. A two-horse, four-shovel corn cultivator.

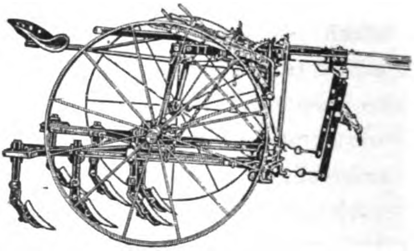

Fig. 12. A two-horse, six-shovel corn cultivator.

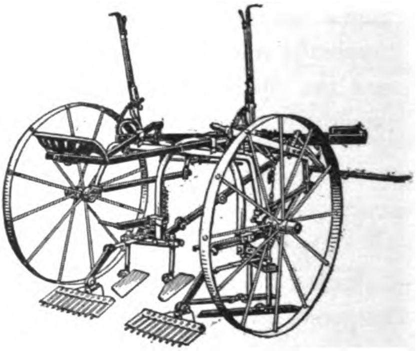

Fig. 13. A surface cultivator with 4 long sweeps.

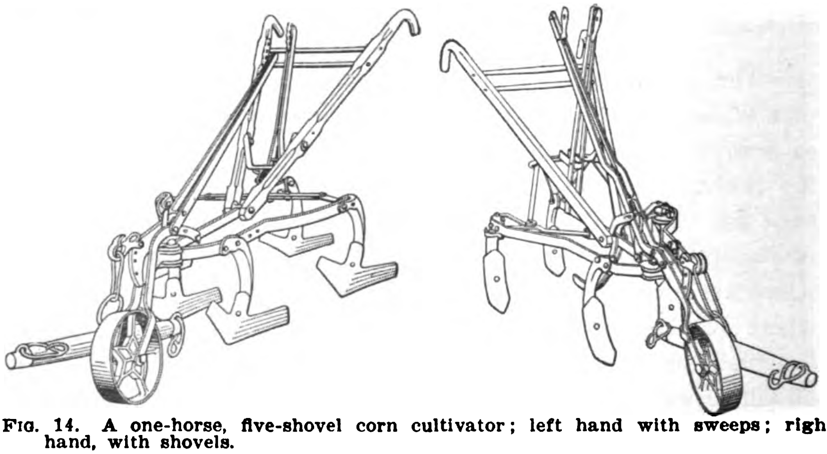

Fig. 14. A one-horse, five-shovel corn cultivator; left hand with sweeps; right hand, with shovels.

the seedbed. The weeder is usually preferred for this latter use, as it has finer teeth than the harrow, is of lighter draft and usually leaves the surface in a finer condition. The weeder can be used until corn or potatoes are about three inches high, but cannot be used on beans after they begin to come through the surface for the stems are brittle.

One horse walking cultivators were once the chief type, but are less popular than formerly owing to the development of the sulky cultivator. They can be purchased in many styles and forms. The earlier forms had two or three large teeth; later four and five slightly smaller teeth were used; and now ten to twelve small teeth are generally employed. The early forms did quite a little of the preparation which was not done before seed planting, and the large teeth were useful in digging out weeds which had gained a foothold. Two tooth cultivators are still used in the South. However, the development of better tools for the preparation of the seedbed, and the spread of the idea that weeds should be killed when small, has wrought a change. The small teeth stir the surface soil more effectively, kill all the weeds and leave the surface in a smooth condition. When much hand hoeing has to be done, the large teeth perhaps are helpful, in that they dig up the soil so it can be hilled up with the hoe. But better methods of weed control by horse machinery have done away with much of the hoeing considered so essential in the early days, which frequently reached its climax on the Fourth of July or on the hottest day in the month.

The one- and two-row sulky cultivators permit one to cultivate much closer to the row than is possible when using the one-horse cultivator, unless it is used twice in a row. Their introduction enables one to handle many more acres and to keep them cleaner than was formerly done by hand. The riding cultivator may be equipped with shovels, sweeps, or a small disc gang. The shovel type is most commonly used in Vermont, although the disc is not unknown. It depends for its action upon its ability to throw the soil to one side; hence it either hills the row or pulls soil away from the row. The sweep consists of long, nearly level blades fastened in the middle, so set as to scrape about one inch under the surface. It is very effective in killing weeds and developing a mulch and it should be more widely used than at present.

DEEP OR SHALLOW CULTIVATION?

Shallow cultivation destroys young weeds and maintains a surface mulch which to be effective in this climate need be but two inches deep. Shallow cultivation is usually to be advised; however, during the first few weeks of growth a deeper cultivation will serve good purposes in that it aerates and warms the soil and hastens crop development. But when the roots begin to spread, the cultivator teeth breaks them if deep cultivation is practiced. This makes it necessary for the plant to send out new roots before it can develop fully its leaf and stem structure. The larger the plant at the time when the roots are broken, the more serious is the result. In fact one of the reasons why late cultivation of corn and potatoes often fails to benefit the crop is that the cultivator teeth are set too deep.

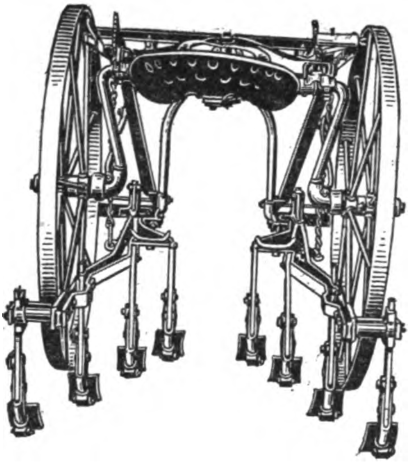

FIG. 15. A two-horse, eight-shovel sulky cultivator.

A farmer was once showing the writer a fine growth of silage corn which was receiving its last cultivation with a one-horse five-tooth cultivator. When the farm hand lifted his cultivator to turn around at the end of the row a festoon of fresh corn roots hung on each tooth. The farmer, remarking that he never supposed a cultivator could do so much damage, hurried it to the barn. On another farm two men were sent one day to cultivate a field of potatoes in blossom. One had a twelve-tooth cultivator with the wheel raised, so it let the teeth about four inches into the soil; the other, a cultivator with blunt teeth that rode up on the soil, giving about two inches penetration. They began in the middle of the field and worked both ways. About a week later the part of the field covered by the first man began to turn brown and to show all the signs of maturity, while the remainder of the field was green and vigorous. The deep cultivation apparently had severed many of the

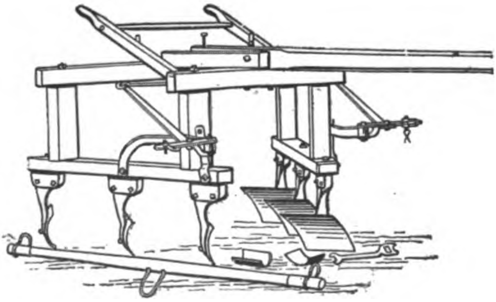

FIG. 16. A two-horse cultivator with scraper instead of shovels.

potato roots and the plants did not have vitality enough to put out new roots before they were shriveled by the sun.

One can determine for himself how deep it is safe to cultivate, by digging down around a plant and finding the first branching roots, and by setting the cultivator to stir the soil at a depth a little less than that at which the roots are active, being careful to set the teeth near the row about an inch shallower than those located in the middle between the rows.

When a corn plant is three feet high, the soil will be practically filled with roots for a distance of two feet on all sides and to a depth of six to eight inches. But little water can get past such a network of roots. But during the early growth and until the plant is eighteen inches high, much soil moisture may be lost by surface evaporation between the rows. Hence the cultivator should be at work often during early growth and cease its activities when the crop reaches a height of thirty inches or more. The depth, time and frequency of cultivation play important parts in producing a good crop.

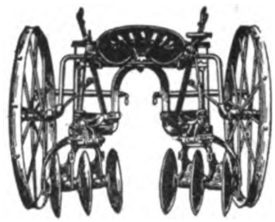

FIG. 17. A two-horse, disc, sulky cultivator.

The Federal Department of Agriculture in its recent (1916) bulletin 320 discusses "Farm Practice in the Cultivation of Crops." Its study was made in twenty different states, located mostly in the corn belt and in the South. The results secured in central Connecticut, in northern Pennsylvania and in central Wisconsin seem fairly applicable to conditions in Vermont, although it is stated in the bulletin that the corn grown in the Connecticut area was in a region where tobacco farms are common and that the tillage methods used in connection with the corn as a rule were those best suited to the growing of tobacco. In each area the tillage practice of from 25 to 30 farmers was carefully studied, more particularly as to the depth of plowing; the nature and number of the tillage operations done after plowing and before planting as well as of the tools used; the nature and number of the tillage operations carried on subsequent to planting; the kind of tillage tools used, the order in which they were, and the extent to which they were used; and, finally, the acre yields were determined in terms of bushels. All these data were accurately secured, the entire study in each case being made on the ground.

It goes without saying that divergence of practice was discovered as between different localities and as between farms in the same region as may be noted in the following tabulated statement. There seems to be no very close connection between high yields and the tillage practice back of these yields on the one hand, and relatively low yields and the tillage practice back of them on the other hand. For example, one Connecticut farmer tilled his crop after planting but once with a two-horse, eight-shovel cultivator. The average number of workings of the soil after planting in the Connecticut area was 3.8. The crop yield where but one cultivation was carried out was exactly the average yield for the entire region. Another farmer in the same section plowed two inches deeper than was done in the case just cited, apparently fitted his land about as well, and cultivated it six times after planting instead of but a single time; and the bushel yield was identical with his neighbors. A study of the tables in the federal bulletin indicates that in general there seems to be no correlation between much tillage and high yields or less tillage and low yields. In short, it seems evident that the tillage factor was not the only one responsible for the crop; that the state of fertility, for example, was also an important item, or, perhaps, the condition of the land as regards drainage.

The following table concisely sets forth the results of these three studies.

	Connecticut		Pennsylvania		Wisconsin	
	Extremes	Mean	Extremes	Mean	Extremes	Mean
Depth of plowing..	6 to 10 inches	7.4	3 to 8 inches	6.1	4 to 6 inches	5.5
Tillage after plowing and before planting	2 to 3 times	2.4	1 to 5 times	2.5	1 to 3 times	1.8
Tillage after planting						
Harrow and weeder	1 to 3 times	0.8	1 to 3 times	0.2	1 to 4 times	2.
Cultivator	1 to 5 times	3.	1 to 8 times	4.2	2 to 4 times	3.4
Total	1 to 6 times	3.8	2 to 8 times	4.4	4 to 8 times	5.4
Crop	17 to 60 bush.	39.9	25 to 50 bush.	38.2	20 to 50 bush.	30.4

It is interesting to compare the implements used in these three sections as judged by these surveys. The Acme harrow was used by 36 percent of the Connecticut farmers, while it was not used at all by the farmers whose tillage practice was under study in northwestern Pennsylvania, or in central Wisconsin. The disc harrow was used by 76 percent of the Connecticut farmers, by 4 percent of the Pennsylvania and by 69 percent of the Wisconsin farmers; the spike tooth harrow by 72 percent in Connecticut, by 29 percent in Pennsylvania and by 100 percent in Wisconsin; the spring tooth harrow throughout the Pennsylvania and nowhere in either the Connecticut or the Wisconsin areas; the plank drag by two of the farmers in the Connecticut area and by one in the Pennsylvania area; the roller was used by one Pennsylvanian and not elsewhere. The Connecticut farmers on the average worked their land 2.4 times after plowing and before planting, those in Pennsylvania 2.5 times, those in Wisconsin 1.8 times.

After planting, 20 percent of the Connecticut farmers went over their fields with the spike tooth, and 96 percent of the men in Wisconsin did likewise; but this tool was not used in the Pennsylvania area. Forty percent of the Connecticut farmers used a weeder, 14 percent of those in Pennsylvania and 54 percent of those in Wisconsin.

In Connecticut, 48 percent of the farmers used a one-horse, one-row, spike tooth cultivator; 56 percent, a two-horse, one-row cultivator with scraper—similar to the Prouty hoe commonly used in Vermont; 24 percent, a two-horse, eight-shovel cultivator; 16 percent a two-horse, six-shovel cultivator; and 16 percent a one-horse, five-shovel cultivator; for an average of 3 cultivations. In Pennsylvania 68 percent used a one-horse, five-shovel; 36 percent, a two-horse, six-shovel; 7 percent a two-horse, eight-shovel; 7 percent a one-horse, two-shovel; and 7 percent the two-horse, one-row with scraper cultivator; for an average of 4.2 cultivations. In Wisconsin, 92 percent of the farmers used the two-horse, six-shovel cultivator; 15 percent, the one-horse, five-shovel; 8 percent, the two-horse, eight-shovel; and 4 percent, the two-horse, ten-shovel, spring tooth cultivator; for an average of 3.4 cultivations.

These data clearly indicate diverse usage of tillage implements in these three sections. Part of this diversity is due to the relative importance of corn as compared with other crops and to the use of implements especially adapted to the tillage of other crops; part to the availability of the machine in question; and part to custom. The Wisconsin farmers used implements similar to those employed in the main corn belt, while in Connecticut potato and tobacco implements are used on corn fields.

HARVESTING MACHINERY

Harvesting machinery constitutes the final group of implements which exert a considerable influence upon soil structure. The potato digger moves considerable soil and does effective tillage work; the root plow used in harvesting beets, carrots and turnips is quite a factor; while the bean puller is not particularly serviceable. The service rendered by the potato digger and the root plow amounts essentially to that of an extra plowing, so thoroughly do they loosen and aerate the soil.

TILLAGE TOOLS WHICH COMPACT THE SOIL

The roller is the best known implement of this class. The results secured from the use of a roller are sometimes disappointing. Bonebright (3) states the case as follows: "It was known that a roller would crush clods and in some cases it might help seeds to germinate. Its detrimental effects when unwisely used were scarcely understood at all. For this reason its use was often a source of loss rather than gain to the farmer * * * The compacting effect of the roller is often completely overlooked by the farmer who wishes to crush a few unsightly clods. The compacted soil may oftentimes do more harm than the clods could possibly do.

Owing to the fact that the particles of earth are brought into closer proximity to each other, capillary action goes on more rapidly in the compacted soil. The moisture in the sub-surface soil is brought to the surface more rapidly and, consequently, the seeds in the dry surface layers—if these layers chance to be dry—receive more moisture than they would if the ground had been unrolled. This is one of the best results which may be secured by the use of the roller. However, the moisture rises rapidly to the surface and is evaporated by the passing currents of air. If one wishes to bring the moisture to within a short distance of the surface of the ground and hold it there, all that is necessary is to roll the field with a properly weighted roller and then harrow the ground with a smoothing harrow. This process forms a dust mulch upon the surface and thus prevents rapid loss of moisture by evaporation."

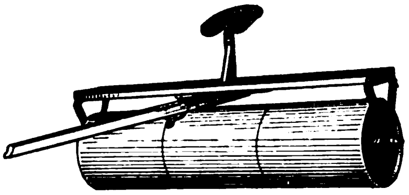

FIG. 18. A smooth land roller, used in seedbed preparation and to compact light, porous soils following plowing.

Eastern farmers, as a rule, if they use the roller at all, employ the smooth form made of wood or cast iron. The dangers are most serious when this type is used. The corrugated rollers are more popular in the West and now are being introduced in the East. The surface corrugations catch, crush and split the clods, while the smooth roller frequently merely presses them into the soil. The corrugated roller leaves the surface in a crumbled condition less favorable to loss of water by evaporation than from the smooth surface left by the plain roller. The most widely used corrugated roller is the disc roller, made up of cast iron wheels with "V" rims set close together. These are durable and efficient. Other forms have longitudinal pipes or rods on the rim of the roller—which are apt to be bent out of shape with use—while still others have flat wheels with irregular projections from the side of the rim—which tend to break off in stony soil. A roller should be from twenty to twenty-four inches in diameter, and should weigh about 100 pounds per foot of width.

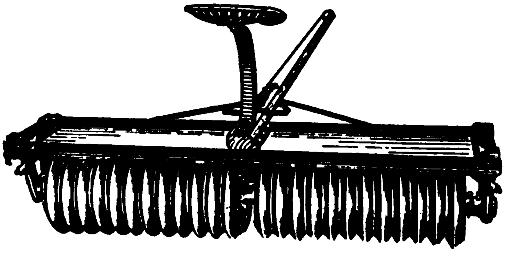

FIG. 19. A corrugated or disc roller or pulverizer, used in seedbed preparation.

The plank clod crusher or drag is a very efficient tool for its special purpose and in cases where the soil should not be compacted as much as by the use of a roller. It is usually a homemade tool consisting of three or more planks so spiked together in overlapping fashion as to catch and crush clods as the tool passes over them. It is perhaps a better pulverizer than the roller since its sliding action seems more effective than the rolling motion. And it does not compact the surface as greatly, and compaction, it should be remembered, may be a benefit or an injury according to circumstances. It does not adapt itself to surface irregularities and one rarely goes joy riding on a plank drag.

The Meeker harrow also splits clods into finer masses. It consists of numerous thin, straight steel discs set on axles with the discs on one axle half way between those on the other and so close to it that the clods have no chance to slip around them. The action of the Meeker is almost entirely one of cutting rather than crushing. It is not widely used.

The Acme harrow (fig. 6, page 73) is an efficient pulverizer. Its twisted blades are set so that they combine the clod crushing of the plank drag with some of the cutting action of the Meeker harrow. It leaves the soil in good condition for a seedbed.

TILLAGE REQUIREMENTS OF VARIOUS CROPS

The general principles of tillage apply to all crops; but certain crops do best with special soil conditions. For example, potatoes require a deep mellow seedbed. This can be secured by spring plowing to loosen the soil just previous to planting, followed by deep and thorough preparation with disc and spike tooth harrows. Obviously the roller should be kept off the field, for a loose and not a compact seedbed is needed. Corn is less fussy than is the potato crop in this respect; yet it needs a deep and well prepared soil. The use of an open wheel corn planter affords all the compaction that is necessary to aid in germination and at the same time will leave the soil loose enough so that the plants can come to the surface. (In this connection see the discussion of corn cultivation in bulletin 189, pages 341-346). Oats, barley and wheat require a finely prepared surface soil, but do best if the soil at three to six inches in depth is quite compact. The knowledge of this requirement has made it possible to economize in power and time required for preparing some soils for these crops. Where oats follow corn or potatoes, it is quite possible to use the disc harrow and prepare a satisfactory seedbed without the use of the plow. Plowing will usually pay where there is an abundance of vegetation to turn under, or on extremely heavy soils that are too compact even for oats till loosened. (In this connection see the discussion of oat planting and cultivation in bulletin 197, pages 56 to 60).

In the winter wheat section of the northeastern United States many farmers instead of plowing use a disc harrow or a sulky cultivator harrow to dig up the surface three to four inches. They save the extra labor and actually secure larger yields than when the soil is over loosened. This practice is confined to the preparation of bean and early potato fields for wheat. It is not so successful where grain stubble is to be followed by wheat.

Successful tillage operations can be accomplished without the use of all the implements briefly discussed in this bulletin. A plow, harrow and one-horse cultivator represent the absolute minimum. A sod plow and a stubble plow for different soil conditions, a disc and a spike tooth harrow, one-horse and a two-horse cultivator, would represent a medium outfit. Double disc harrow, roller, weeder, Acme harrow, a deep tilling machine, and several cultivators are implements that are highly desirable. The small farm cannot afford these because the investment becomes too heavy. Large sizes make for rapid tillage, so that one can take advantage of favorable moisture conditions and prepare a seedbed with a minimum of labor. Here again the small field is handicapped. The use of new and improved tillage implements on medium to large fields and on level farms represents one of the handicaps which the hill farm always will have to contend with. It is best solved either by joining two or more hill farms into one, or by growing hay and pasture on the land too rough to work with ease.

REFERENCES

The following publications have been referred to or used in the preparation of the preceding article. Persons interested in the further study of tillage operations will find several of these well worth reading.

1. Bailey, L. H. Treatment of Soil by Means of Tillage. (Introduction Chap. XI). Cyc. Amer. Agr., 1, pp. 372-378. The Macmillan Co., New York (1907).
2. Blake, F. D. Tillage Implements. Trans. Amer. Soc. Agl. Eng., 3, pp. 21-30 (1909).
3. Bonebright, H. B. Land Rollers. Trans. Amer. Soc. Agl. Eng., 3, pp. 13-20 (1909).
4. Carden, P. V. Tillage and Rotation Experiments at Nephi, Utah. U. S. Dept. Agr., Bul. 157 (1915).
5. Cates, H. R. Farm Practice in the Cultivation of Corn. U. S. Dept. Agr., Bul. 320 (1916).
6. Cates, J. S., and Cox, H. R. The Weed Factor in the Cultivation of Corn. U. S. Dept. Agr., Bu. Plant Ind., Bul. 257 (1912).
7. Chase, L. W. Instruction in Farm Machinery. Trans. Amer. Soc. Agl. Eng., 1, pp. 51-62 (1907).
8. Corbett, Wm. Horse Hoeing Husbandry, by Jethro Tull. Pub. by Wm. Corbett, London, Eng. (1829).
9. Davidson, J. B. Agricultural Engineering, pp. 199-243. Webb Publishing Co., Minneapolis, Minn. (1913).
10. Davidson, J. B., and Chase, L. W. Farm Machinery and Farm Motors. Chaps. IV, V, pp. 51-101. Orange Judd Co., New York (1908).
11. Demaree, F. H. Larger Farm Implements and the Cost of Crop Production. Trans. Amer. Soc. Agl. Eng., 5, pp. 26-41 (1911).
12. Ellis, L. W., and Rumley, E. A. Power and the Plow. Doubleday, Page & Co., New York (1911).
13. Gould, J. S., et al. Report committee on trials of plows. Trans. N. Y. State Agl. Soc., 10, pp. 48-69 (1850).
14. Gould, J. S. Trans. N. Y. State Agl. Soc., 26, pp. 148-166 (1866).
15. Hall, A. D. The Soil. Chap. IV, pp. 84-110. E. P. Dutton & Co., New York (1905).
16. King, F. H. Physics of Agriculture. Chaps. V, VII, VIII, XI, pp. 129-141, 158-203, 223-254. Author, Madison, Wis. (1901).
17. King, F. H. Tillage: its Philosophy and Practice. *In.* Cyc. Amer. Agr. (Bailey) 1, pp. 378-398. The Macmillan Co., New York (1907).
18. Lyon, T. L., Fippen, E. O., and Buckman, H. O. Soils—Their Properties and Management. Chaps. X-XIII, XXIX, pp. 170-288, 663-681. The Macmillan Co. (1915).
19. Ocock, C. A. The Draft of Plows. Trans. Amer. Soc. Agl. Eng., 6, pp. 13-30 (1912).
20. Roberts, I. P. The Fertility of the Land. Chaps. II-IV, pp. 34-119. The Macmillan Co., New York (1900).
21. Sanborn, J. W. Plows and Plowing. Mo. Agl. Coll., Bul. 32 (1888).
22. Sanborn, J. W. Plow Trials. Utah Sta., Bul. 2 (1890).
23. Snyder, W. P., and Osborn, W. M. Rotation and Tillage Methods in Western Nebraska. Nebr. Sta., Bul. 155 (1915).

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CONCERNING THE USE OF COMMERCIAL FERTILIZERS IN 1916

The present situation in the commercial fertilizer trade is utterly unlike anything hitherto experienced. The line of reasoning on which manufacturers heretofore have proceeded in the formulation of their mixtures and the experiment station and extension service people have proceeded in proffering suggestions to farmers as to the use of plant food, no longer in all respects is valid. It has seemed desirable, therefore, to set forth the causes which have brought about this situation and succinctly to indicate desirable procedures for the coming year. The directors of the Experiment Stations of the North Atlantic States (other than Pennsylvania) met on November 29 to review the situation. This circular is born of their meeting and in a general way represents their united judgment as to the wisest procedure in view of the untoward circumstances now confronting New England farmers; not that its suggestions will be applicable universally—for there are many sorts of soils and many kinds of farming—but perhaps in some degree they may be helpful in a trying situation.

I. 1916 Trade Abnormalities

1. The commercial potash supply practically is exhausted and none is in sight. A few manufacturers of commercial fertilizers will sell not to exceed one percent in some of their brands. Pacific kelps, certain western mineral deposits and various processes now in an experimental stage, may afford relief at some future time, but so far as 1916 crops are concerned, potash is a negligible quantity. Muriate is quoted at $530 a ton, thirteen times its normal price.

2. Upwards of a half million tons of sulphuric acid, ordinarily used in making acid phosphate, have been diverted to the manufacture of munitions. Naturally this has affected the market prices of acid phosphate and of mixed goods. It is only just to the fertilizer trade in this section of the country to say that, in many instances at any rate, it has refused to sell its acid, not on account of altruistic motives but because it looks beyond 1916 and immediate profits to the holding of its business in succeeding years.

3. The European export business in phosphate rock has ceased, many Florida phosphate mines have closed or work only part-time, and a curtailed supply is being secured at a higher cost.

4. Coastwise freights have increased greatly in cost, owing to war conditions.

5. In part, at least, on these accounts, acid phosphate has gone up in cost within the past few weeks like an ascending rocket and it does not seem as yet to have reached the heights. It has jumped nearly a dollar in price during the past two weeks and is now quoted at practically twice the sum at which it was offered in early September. It now wholesales at so high a price—it is quoted at $14—as to be at the extreme limit of its agricultural value. Farmers well may hesitate to pay present prices for acid phosphate whether offered in mixed goods or crude stock; yet there is no adequate substitute for it.

6. Nitrate of soda is relatively scarce and quoted at high figures: $65 a ton in mid-December as compared with $49 in mid-August. It is used largely by the munitions trade, and, being mined only in Chili, present deliveries are delayed by the blocking of the Panama Canal and the long detour around Cape Horn. It is now, so far as farmers are concerned, to be looked upon as a luxury.

7. Sympathetically, other forms of plant food seem to have moved upwards in their wholesale quotations. Thus, for example, cottonseed meal, which is largely used in fertilizer manufacture in the South and very freely in Connecticut in the tobacco regions, sold f.o.b. southern shipping points in mid-August at $23, but from November 1 to mid-December it has ranged from $31 to $33.50 at southern points. Wholesale seaboard quotations on sulphate of ammonia have increased in the same time from $71 to $80; since November 1 about $4 a ton more has been asked for tankage than was asked in August; dried blood has jumped from $32 to $41 and fish scrap from $31 to $43. Bone and raw phosphate rock have not changed, and cyanamid thus far has increased but about 10 percent on its late summer prices. Refined potash salts have more than doubled in price since August, selling now at approximately $500 a ton, although kainit is still quoted at $40 flat.

II. FUNDAMENTAL CONSIDERATIONS

What should farmers do, now that potash is lacking and fertilizers are costly? Recourse should be had to the fundamentals.

1. Adequate tillage operations should be carried on, since they tend to set free plant food and to maintain a satisfactory soil water

supply as well as in other ways to increase the likelihood of satisfactory crop growth. (In this connection, see the article on "The Philosophy of Tillage," in the first report of the State Commissioner of Agriculture for 1909, pages 114-119; free for the asking of Hon. E. S. Brigham, Commissioner of Agriculture, St. Albans, Vt.).

2. Home manurial resources should be carefully conserved. Special effort should be exerted to prevent all liquid manure wastes, since nearly all the potash in the food as well as the more soluble nitrogen is excreted in the urine. More and better absorbents should be used and stable floors should be made water-tight. Leaves, waste stalks, trash of many sorts are worth saving and may be worked over by pigs. The earth beneath leaky stables or pens or in open yards or pens where cattle have been confined, may be scraped off and used to advantage, since it is apt to contain a good deal of potash as well as other forms of plant food. Peat beds and muck swamps may be turned to advantage, the material being used on the land directly, used, with care, as absorbents, or composted with barnyard manures, etc. Samples of peat or muck which are taken in accordance with methods furnished on request by the Vermont Station will be analyzed without charge. (In this connection see Vermont Bulletin 165 on "the Peat and Muck Deposits of Vermont"; free for the asking of the Station; also Farmers' Bulletin 192 on "Barnyard Manures," free for the asking of your Congressman or of the United States Department of Agriculture, Washington, D. C.).

3. It may be well to apply farm manures more promptly than usual and, also, to spread them more thinly. There is some reason to believe that lighter dressings used over larger areas would be a better procedure than that commonly employed.

There is a wide variation in manures, owing to differences between species of animal, feeds, care, beddings, and to other causes. Speaking in general terms, however, a ton of average manure carries about 10 pounds of nitrogen, 10 pounds of potash and 7 pounds of phosphoric acid and a cord carries from two and a half to three times as much, though a cord of horse manure may contain but two tons. The urine contains practically all the potash, as already has been remarked. Manure may be used this year on crops which ordinarily are grown solely on commercial fertilizers.

If for any reason manure is stored, more than usual care should be taken to compact the pile, to make its sides nearly vertical and to seek to lessen moisture losses.

4. Wood ashes, lime-kiln ashes, brick-kiln ashes and the like, should be saved carefully; but they *should not* be mixed with hen manure or commercial fertilizer containing acid phosphate.

5. Liming often will prove worth while. Most Vermont soils are acid and respond well to lime. Lime in the form of limestone, marl, quick or slaked limes does not seem to make soil potash available; but lime in the form of gypsum or land plaster is thought to some extent to accomplish that end. (In this connection see Vermont Station Bulletin 160 on "Limes and Liming"; free for the asking).

It should be said further, since in 1916 farmers will need to scan their fertilizer purchases with unusual care and, perhaps, to curtail them, that they may turn their energies with propriety for the time being to other means of soil improvement, to underdrainage, to irrigation, and to crop rotation. Such as may be thus minded are referred to Vermont Station bulletins 173 (drainage), 182 (irrigation), and 190 (crop rotation), any or all of which are free for the asking. Indeed it is not too much to say that a healthy soil is to be preferred to great riches; that adequate humus and lime contents, a non-acid condition, ample but not excessive water supplies, and good tilth, are necessary precedents to successful fertilization in any year, and especially in 1916.

III. CONCERNING SOURCES OF PLANT FOOD

NITROGENOUS. Both mineral and organic forms should be used for general crops.

Nitrate of soda of course ranks higher in availability than any other nitrogen-bearing crude stock. In this northern land where many crops must mature in a relatively short season, the quickest nitrogen is none too rapid promptly to start a crop. Hence it is that the writer long has held that under normal trade conditions, and, speaking broadly, at least one-third of the nitrogen in a commercial fertilizer—and more than that proportion if the lower grades are used—should be furnished as nitrate. This is especially true in the northern counties, on the higher altitudes throughout the State, and on the heavier soils. However, the trade conditions of 1916 are such that it may be difficult or impossible to secure adequate supplies of nitrate. It may be necessary —it will be quite sure to be more economical—to use sulphate of ammonia or calcium cyanamid in its stead.

Sulphate of ammonia is less well known than is nitrate to Vermont farmers. It is soluble in water and its nitrogen is readily available to plant growth, though less readily than that in nitrate. It is at the present writing so much cheaper, pound for pound of nitrogen, as to cause it to stand more nearly on a par than usual with nitrate nitrogen on an availability basis. Usually it is not thought to be quite as likely to afford immediate results early in the spring as is nitrate; hence the writer's predilection for the former salt. This is not gainsaying the thorough reliability and usefulness of the sulphate.

Calcium cyanamid as now manufactured seems to be well worth using and recent quotations are eminently satisfactory. Indeed, it is the cheapest available nitrogen now offered. Not more than 200 pounds per ton should be used. In some cases it has seemed to exert a slightly toxic or poisonous effect on the crop and to delay spring germination, a more serious matter in Vermont than in states further south. Temporarily it may irritate the skin and eyes, but only temporary annoyance is to be feared. It is not externally poisonous to man or beast. Its alkalinity and free lime content necessitate its restricted use in mixed goods, 200 pounds being the limit. It may be used mixed with nitrate but not with sulphate of ammonia. Unless used quite promptly after mixing with acid phosphate, to some extent it may impair the availability of the phosphoric acid. It seems to rank with or slightly lower than sulphate of ammonia in its availability, as judged by vegetation tests, and at the outset is not as rapid in its effect as nitrate. On these accounts it may be well to apply a fertilizer containing cyanamid from seven to ten days before seeding.

Organic forms. The buyer of crude stock will do well to get quotations and buy organic nitrogen when he can do so to best advantage, provided its availability is satisfactory. Tankage usually will be chosen. Peruvian guano may be worth considering, although offered at very high prices. Cottonseed meal now is held at high prices and on this account is less likely than usual to be considered.

Farmers should not forget that peat and muck are nitrogenous, though their nitrogen contents relatively are inert; that average manure, if well kept, carries about 10 pounds of nitrogen in a ton and from 25 to 30 pounds in a cord; and that some manufacturing wastes—wool or felt waste for example—are worth using. (In this connection the discussion of the nature of nitrogenous crude stock used for fertilizer purposes on pages 298 to 305 of Vermont Station Bulletin 182 may prove interesting and helpful. It is free for the asking).

PHOSPHATIC. Available phosphoric acid tends to hasten the development of the root system of the crop. Hence it works especially well in starting crops early, enabling them to profit by a longer growing season and making it possible for them to utilize plant food in the soil which otherwise might not be reached.

Acid phosphate, of course, is the most available and best form of phosphatic plant food; but its present inordinately high price will be likely to discourage its use, even on quickly growing crops. Yet it will be used largely, for most commercial brands are built on an acid phosphate basis. More than ever its use should be confined to naturally productive lands and to cash crops.

European basic slag is not in the market. A limited quantity of southern slag of fairly good quality is on sale at a rather high price and may be used to advantage on grass and orchard lands.

Bone meal (raw, or steamed) and *tankage* are relatively slow purveyors of phosphoric acid, although in some cases they have been found—especially the steamed product—to approximate in serviceability to acid phosphate when used for corn and to answer fairly well with other crops, particularly those which are not quick growing but are long-season crops. It tends markedly to improve the texture of mixed goods, to better their physical character.

Floats (ground phosphate rock) are not advised for use in northern New England with the generality of crops. Its phosphoric acid is the slowest of the slow, even when used so superabundantly that a money equivalent of acid phosphate at present high prices is afforded. The field results are not likely to be satisfactory, although at times, on some slow growing crops, like rape, for example, which seem to possess unusual foraging powers, successful results have been attained. Perhaps satisfactory returns may be secured after a considerable lapse of time, but New England farmers buy plant food primarily for a quick turnover and not to put in the soil bank. Favorable results have been attained with floats in some cases when used as a reinforcement of manure which lies for some months to heat and ferment; in others no gains have been noted. When turned under with green manuring crops, or when used on strongly acid soils with crops like potatoes or onions, some results which seem favorable have been secured; but it is quite certain, even under the abnormal conditions of the coming season, that Vermont farmers should not resort to ground phosphate rock for the fertilization of their money crops or their quick growing crops. (In this connection the discussion of the nature of phosphatic crude stock for fertilizing purposes on pages 305 to 310 of Vermont Station Bulletin 182, may prove helpful. It is free for the asking).

POTASSIC. *German potash salts* (muriate, sulphate, kainit) are not for sale. Muriate of potash now is quoted nominally at $530 or more a ton. It sells normally at about $40 a ton. No farmer can afford to buy it, and few farmers can get it in any quantity.

Wood ashes, lime-kiln ashes, brick-kiln ashes, etc. These materials contain more or less potash, generally less. At best a good grade of wood ashes may carry five percent; as a rule they are likely to carry much less than this. They are selling, delivered at New England points, in somewhat limited quantities in carload lots at from $13 to $15 a ton. Assuming a five percent potash content—a liberal assumption—and remembering that ground limestone is offered f. o. b. at Vermont shipping points in carload lots at $1.50 a ton, the potash in high grade wood ashes would cost approximately ten cents a pound. If the ashes are of as poor grade as are offered commonly, a pound of potash may cost 20 or 30 cents a pound. Parties expecting to buy ashes should write the Station, ask how properly to draw samples, and then submit carefully drawn samples to the Station for its free analysis; for buying ashes in the open market nowadays is like "buying a pig in a poke." Wood or other ashes should not be used in combination with nitrogenous materials or acid phosphate, as they induce their deterioration. (In this connection the discussion of the nature of potassic crude stock for fertilizing purposes on pages 310 to 312 of Vermont Station Bulletin 182 may prove helpful. It is free for the asking).

WHAT MAY BE USED AS A SUBSTITUTE FOR POTASH?

There is no thoroughly adequate substitute for potash. Any procedure which may be carried out must be of a makeshift character and relatively unsatisfactory. However, the following suggestions are offered: In the first place wood ashes may be resorted to as a direct supply, as is indicated above; then, recourse may be had to certain so-called indirect fertilizers, more particularly common salt and land plaster; and, finally, reliance may be placed on the subsidiary effects produced by the use of nitrate of soda and acid phosphate.

Common salt. "Salting meadows" is an old time farm practice, long discontinued on any large scale, but worth reviving in 1916. Salt seems to act favorably to some extent with some crops on some soils. Its soda content is thought to replace and to liberate more or less soil potash; to act, in other words, in part as a substitute for potash, to make what potash there is "go further." In a general way the trend of results seems to indicate rather better results with grass than with other crops. Potatoes do not seem to respond, since in several careful trials no benefit occurred. An overdosage is likely to cause lime losses in drainage waters, and on this account, presumably, to increase soil acidity. It is thought by some to render the crop more susceptible to frost injuries. From 150 to 250 pounds to the acre may be used. Refuse salt can be bought of Hon. C. S. Page, Hyde Park, Vermont, at the rate of $4 a ton f. o. b. factory in ton lots. The International Salt Co. of Watkins, N. Y., is said to be quoting $2.50 a ton, f. o. b., Watkins. Apparently salt can be laid down at Vermont points from $4 to $7.

Lime (as gypsum, land plaster). There appears to be a popular notion afloat that lime, in the form of ground limestone, quick or slaked lime, may liberate soil potash. Under average conditions it is doubtful whether lime in these forms may be depended upon materially to increase the available soil potash supply. Doubtless it may serve to release and to render available the potash in organic matter, whether in green manures, plowed-under sward, stubble, farm manure, or organic soil constituents containing potash. However, when applied in the form of gypsum or land plaster, its effect as a soil potash liberator seems more clearly established; yet there are plenty of instances where in this respect it seems to have been inert. Land plaster is not offered commonly in Vermont nowadays and is relatively costly. However, used in the stable, sprinkled in the trenches for the purpose of lessening fermentative losses, doubtless it is well worth using; and, as in the case of nitrate of soda, its effect as a potash purveyor, if any such there is, can be looked upon as a by-product. Probably it is best applied to the soil by way of the stable.

Nitrate of soda. Careful and long continued field trials in England seem clearly to indicate that soil potash to some extent is liberated by the application of nitrate of soda. In this respect it acts much as does salt. Similar trials elsewhere, including some New England points, have not shown the same tendency. However, since nitrate of soda is worth using in moderation for its own sake, its effect as a soil potash liberator, if any such exists, may be accepted as a by-product.

Acid phosphate contains about forty percent of artificial gypsum or land plaster, which serves the same purpose as does the natural product. The buyer of acid phosphate, either as such or in mixed fertilizers—of which it is almost always a principal ingredient—secures several services. If acid phosphate is used, as it may be to advantage, in the trenches at the rate of a pound a day per animal, it tends to save nitrogen, it directly supplies available phosphoric acid, it may free soil potash, and it carries a large lime content in the form of land plaster. *Multum in parvo!*

In this connection it may be said that there seems reason to believe that attempts will be made to sell ground rocks to farmers on the basis of their potash content. Water-insoluble potash in the form of ground rock is not to be relied upon at this juncture. Some day soluble potash will be extracted in a commercial way from feldspar and other potash-bearing rocks, but that day is not today; and, furthermore, this fact has no bearing on the purveyal of insoluble forms of potash. Farmers should buy no materials said to contain potash except on the basis of their guaranteed water-soluble potash content; and they should buy no so-called "potash liberators" without a clear knowledge of their nature. Samples of a doubtful character should be submitted to the Station.

IV. Is Potash Necessary?

How necessary will potash be in 1916 crop growth? The writer is inclined to believe that if the growing season of 1916 is a fairly good one, Vermont farmers will not suffer seriously for lack of potash in the growth of the generality of crops, provided they conserve and intelligently use their home resources and, perhaps, make use of indirect fertilizers or of nitrate of soda and acid phosphate, either in ready mixed or home mixed goods. This faith is based in part on what he deems to be his general knowledge of the past history of Vermont soils, their fertilization and cropping, and in part on the results attained at various points throughout New England.

On the Rhode Island station soils, potash seems relatively unimportant for most crops, other than potatoes, nitrogen and phosphoric acid being relatively more important. Roots, onions, oats, hay and corn, do not respond to potash. On two soils during four seasons, potatoes averaged 20 and 40 percent crop increases, following potash fertilization.

At the New Hampshire station, potash showed little effect on grass.

On the Aroostook (Maine) station farm during the past year, the use of potash, together with a liberal nitrogen and available phosphoric acid supply, increased the potato crop only 7 to 10 percent over that secured when potash was not used.

During the past year in some 70 trials throughout New England on corn and potatoes, a fertilizer carrying approximately 4 percent nitrogen and 10 percent available phosphoric acid seemed to do about as well as did a brand carrying 3¼ percent nitrogen, 8 percent available phosphoric acid and 4 percent potash.

It is only right to say, on the other hand, that potash long has been recognized to be the dominant element on the silt-loam soils at the Massachusetts station in the Connecticut valley; and that at the New Jersey station some twenty trials have shown that fertilizers containing potash have outclassed those containing none.

Soil, crop and season are prime controlling factors; and sweeping statements of general application are not worth the paper they are printed on. But why worry? Let us save all the potash we can, do our best to make use of soil potash, buy none whatever unless we can get good and cheap wood ashes, and sleep soundly!

V. Specific Suggestions as to Soils

1. This is not the time to stress the permanent enrichment, the "building up," of soils by means of purchased plant food.
2. This is not the time to try to grow money crops on the lighter and sandy types of soils. Some special high cost crops may be thus grown; but these are exceptions.
3. This is the time to use the best soils for money crops.
4. This is the time to remember that the heavier soils as a class contain more potash than do the lighter and sandy soils; that, just as in normal times the former are less likely to respond profitably to the application of potash than are the latter, so now they are less likely to suffer for the lack of such application and more likely to produce a normal yield of crops that use potash freely.
5. This is the time for farmers who have used potash somewhat liberally thus far, to bear in mind the previous history of their various fields as regards fertilization and cropping and, to a reasonable extent, to be influenced thereby in their 1916 cropping plans.
6. This is the time for farmers carefully to estimate the probable commercial value of each crop and to use this estimate as a measure of spring plant food usage; to remember that on special crops necessitating high labor costs (e. g. onions, tobacco, which are grown only in a small way in Vermont) fertilizer charges are relatively unimportant; and to remember, on the other hand, that low money value crops, such as are grown commonly in extensive farming practice, will not as a rule repay excessive fertilizer charges.

VI. Specific Suggestions as to Crops

1. *Topdressing grass lands.* Nitrate of soda, 100 to 200 pounds to the acre, easily is the best application for immediate returns, al-

though half nitrate and half calcium cyanamid sometimes has worked well. In some instances repeated applications of nitrate have resulted unfavorably, the grass running out; in other instances no such outcome has been observed. The New Jersey station reports a gain of two tons of hay following a 225 pounds nitrate of soda application. The Maine station applies 100 to 150 pounds dissolved in water, using a potato sprayer for this purpose, thus securing an even and thorough application at a slightly increased cost. In this connection the possible effect of nitrate of soda as a potash liberator should not be forgotten.

Sulphate of ammonia may be used advantageously at the rate of 100 to 150 pounds per acre if employed in conjunction with plenty of lime or on a neutral soil and if used somewhat earlier than one would use nitrate. If in dried and ground form, it can be applied accurately and easily with grain drill. It should not be used in conjunction with cyanamid.

The highly nitrogenous commercial brands may be used to advantage.

(In this connection see the somewhat extended discussion of the topdressing of grass lands on pages 189 to 191 of Vermont Station Bulletin 171; free for the asking).

2. *Topdressing clover and alfalfa.* Normally, basic slag and potash salts, in the proportions of three to one, 500 to 800 pounds to the acre, have proved satisfactory; but neither now are to be had at reasonable prices. Acid phosphate and wood ashes applied separately, perhaps in equal parts, say 600 to 900 pounds to the acre, seem on the whole most advisable; but both are costly and one, perhaps, is of doubtful quality. Hence the writer is inclined to believe that perhaps 1916 may be a good year in which to forget to topdress these crops. (In this connection see the discussion of topdressing on pages 190 to 191 of Vermont Station Bulletin 171; free for the asking).

3. *Corn.* The ordinary practise is advised, namely, 4 to 6 cords, or 10 to 15 tons, of manure, supplemented with 300 to 500 pounds of a fertilizer—either ready mixed or home mixed goods—containing about 2½ to 3 percent nitrogen and about 10 percent of available phosphoric acid. About one-third of the nitrogen ought to be supplied in the form of nitrate of soda, if possible, both on its own account and because of its possible effect as a potash liberator; if this does not seem possible, sulphate of ammonia or calcium cyanamid may serve, but not sulphate of ammonia *and* calcium cyanamid, since they are "incompatibles." In the event that no manure is used, a rare occurrence in Vermont, the usage of the commercial goods may be increased by

at least two-thirds; and, in the writer's judgment, the likelihood of a profitable outcome will be apt to be decreased. (In this connection see the discussion of corn fertilization on pages 346 and 347 of Vermont Station Bulletin 189; free for the asking).

4. *Oats, barley, seeding down to grass.* It is, of course, a common procedure to sow grain following corn directly or with a year's interval, depending upon the residual plant food for the forcing of crop growth. If a fertilizer is used at all, nitrate of soda may be sown in small amounts, or a 300 to 500 pound application may be made in the spring of a ready mixed or home mixed goods carrying 4 to 5 percent nitrogen and 8 to 10 percent available phosphoric acid. The nitrogen should be used largely in the mineral form, and preferably as nitrate for reasons hitherto cited, though cost considerations may make it impracticable to do this. If the seeding is done in the fall, or if winter rye is sown, no nitrate should be used. (In this connection see the discussion of seeding down fertilization for grass, oats, barley and clover on pages 186 to 189 of Vermont Station Bulletin 171; free for the asking).

5. *Potatoes, vegetables, small fruit.* Farm manure may be used if fairly well decomposed and if worked well into the soil, perhaps five tons to the acre, together with about 500 pounds of a ready mixed or home mixed goods carrying from 2½ to 3 percent nitrogen and 8 to 10 percent available phosphoric acid, approximately one-third of the nitrogen to be preferably in the form of nitrate, for reasons hitherto advanced, although cost considerations may make this impracticable. On the other hand where scab is feared, sulphate of ammonia which tends, if anything, to acidify soils may serve the purpose better than nitrate. The manure will furnish from 40 to 50 pounds of potash and the nitrate of soda, and, also, the artificial gypsum or land plaster of the acid phosphate, which is used in all fertilizers, may help out the scanty potash supply. To some extent the manure may increase the likelihood of a scabby potato crop, but the scab, like the poor, always is with us and even with the utmost care often cannot be avoided. Ashes may be used to the extent of 1,000 pounds if broadcasted and worked in carefully. They should be separately applied. Their effect on scab is quite likely to be unfavorable. However if potato growers plant a russet variety, such for example as the Cambridge Russet, Burbank's Russet, Dibble's Russet or Scab Proof, the likelihood of scab injury is but slight.

If no manure is used, a considerably larger amount, upward of 1,000 pounds, of a goods carrying perhaps 4 percent nitrogen (5 percent ammonia) and 8 to 10 percent available phosphoric acid may be used, preferably 10 percent.

Many potato growers doubtless will feel like buying goods carrying one percent potash in order to get some potash. This does not seem to the writer to be a case where a half-loaf is better than no bread. It is but a sixth of a loaf. The one percent will be costly and will be but a drop in the bucket, but five pounds in a 500-pound application. While the results of field trials are very conflicting and it is difficult to deduce definite results which are of general application, there seems a fair consensus of opinion among those whose experience entitles them to express an opinion to the effect that small applications of potash are quite ineffective in potato growing. The North Atlantic State directors are a unit in their belief that under the peculiar conditions of the coming season ammoniated superphosphates without potash usually are to be preferred to one percent potash goods.

6. *Orchards.* The results of orchard fertilization trials are highly dissimilar. Long continued work in New York and in Maine has resulted negatively. On the other hand, a famous Massachusetts orchard has responded wonderfully to fertilization. Under the conditions of this year, adequate tillage together with winter covers seems the safer procedure. Indeed, moisture conditions and not the plant food supply seem controlling factors in orchard management.

VII. What Sort of Commercial Fertilizers Will Be Sold?

The fertilizer manufacturers selling in Vermont have not listed their 1916 brands at the time when this circular is being issued; but it is clear from the statements voluntarily made by trade representatives that a few brands carrying 1 percent of potash will be offered; that a large proportion of the brands will carry no potash; that the available phosphoric acid contents almost invariably will be confined within narrow limits, from 8 to 10 percent; and that the chief variations this year as between different brands will be in the nitrogen contents, which will range from 0.8 (1 percent ammonia) to 4.9 percent nitrogen (6 percent ammonia). There seems no reason at present to believe, on account of the untoward conditions now existing, that either the quantity or quality of the plant food which will be sold by the fertilizer trade will be inferior in any respect to that hitherto furnished by the manufacturers selling in Vermont, save, of course, that potash will be a minus quantity.

VIII. Should Ready Mixed or Home Mixed Goods Be Used?

Vermont farmers have been buying crude stock and mixing at home to a greater extent this past year than ever before—generally with satisfactory results, both as to money saving and crop growth. Less satisfactory results are likely to be secured in 1916. Fertilizers and fertilizer crude stock will cost much more than formerly; and, since potash is a minus quantity, the field results may be affected.

When conditions are normal, crude stock may be bought for cash in large quantities in cooperation at lower prices than those at which mixed goods can be purchased in large quantities for cash; but it may be in this unusual year that better trades can be made in mixed than in unmixed goods. For most of the mixed goods were made when nitrate sold at $49, sulphate of ammonia at $71, when tankage sold around $30, acid phosphate at $7; whereas these articles are now quoted at wholesale at the seaboard at approximately $65, $80, $35 and $14 respectively. Some brands carry one percent of potash.. Muriate of potash sold in August at $250; it is now quoted at $530. Buyers of crude stock who seek to place their orders this winter will of course be handicapped as compared with those whose orders were placed in mid-summer—and few such exist—or with manufacturers who buy throughout the year. It well may be that farmers can get more for their money in 1916 by buying the ready made goods, made when materials cost less than they do now, than by buying high-priced crude stock. It is for each man to figure the relative costs and buy accordingly. In this connection it may not be amiss to say that nitrate nitrogen probably can be bought to better advantage in 1916 in mixed goods than in crude stock; and nitrate of soda is a most valuable form in which to supply Vermont crops with nitrogen.

Because of high prices farmers more than ever should endeavor to make a dollar go as far as it will; should get quotations from several manufacturers or dealers; should pay cash, if possible, for the reason that credit purchases cover high interest charges; should buy in cooperation with others, as so many Vermont farmers are now doing; and should buy on a guaranty basis.

Summary

1. Commercial fertilizers and the materials from which they are made will cost more in 1916 than hitherto, because:

(a) The available potash supply is exhausted.

(b) The munitions trade is using much of the material hitherto employed in commercial fertilizer manufacture; more expecially sulphuric acid and nitrate of soda.

(c) The phosphoric mines are largely shut down.

(d) Coastwise freights are scarce and high.

(e) The blocking of the Panama Canal temporarily has hindered nitrate importations.

(f) Practically all forms of crude stock have risen in price sympathetically.

2. In this juncture farmers should:

(a) Till their soils to best advantage.

(b) Husband home manurial resources, especially the liquid manure.

(c) Apply manure more carefully.

(d) Conserve all wood ashes.

(e) Lime acid soils.

(f) Pay more than usual attention to underdrainage, adequate crop rotation, etc.

3. Concerning plant food sources:

(a) *Nitrogenous.* Nitrate of soda is costly, but is the most available form of nitrogen; sulphate of ammonia is well worth using; and calcium cyanamid is the cheapest form of nitrogen now being offered, though open to minor objections. Tankage and other approved organic ammoniates are costly, but as a rule are necessary.

(b) *Phosphatic.* Acid phosphate is very costly but by far the most available source of phosphoric acid; bone meal and tankage are fairly satisfactory forms; basic slag practically is unattainable; floats (ground phosphate rock) should not be relied upon for use in northern New England.

(c) *Potassic.* Potash salts are not for sale; wood ashes, etc., should be saved carefully and, if bought, should be purchased on guaranty and analysis; ground feldspar, etc., is quite useless as a purveyor of potash.

(d) Potash substitutes do not exist. However, certain materials, salt, land plaster, nitrate of soda, acid phosphate, under some circumstances, seem to free soil potash. Their use is advised in a limited way.

4. Vermont farmers probably can get along in 1916 without much purchased potash. This judgment is based on past experience and experiment. They will have to, anyway.

5. Suggestions as to soils.

"Permanent agriculture" and the attempted growth of money crops on light and sandy soils are not for 1916. The best soils, well handled, are none too good. Heavy soils will best withstand a shortage of manurial potash. More carefully in 1916 than ever before, the relation of the probable cash value of the crop should be weighed against a proposed expenditure for plant food.

6. Suggestions as to crops:

(a) *Topdressing grass lands.* Nitrate of soda 100 to 200 pounds, or a half nitrate and half cyanamid application, 100 to 200 pounds, or 100 to 150 pounds of sulphate of ammonia may be used. The highly nitrogenous commercial brands may be used to advantage.

(b) *Topdressing clover and alfalfa.* Wood ashes, if obtainable, probably are the best thing to use in view of the conditions of 1916.

(c) *Corn.* Four to six cords (10 to 15 tons) manure and 300 to 500 pounds of a fertilizer carrying about 2½ to 3 percent nitrogen (one-third as nitrate if practicable; if not either—not both—cyanamid or sulphate of ammonia) and about 10 percent available phosphoric acid are suggested.

(d) *Oats, barley, seeding down.* Nitrate of soda in the spring in small amounts, or a 300 to 500 pound application of a fertilizer carrying 4 to 5 percent nitrogen (largely mineral) and 8 to 10 percent available phosphoric acid may be employed.

(e) *Potatoes, vegetables, small fruits.* Five tons of well rotted manure and about 500 pounds of a fertilizer carrying 2½ to 3 percent nitrogen and 8 to 10 percent available phosphoric acid, the nitrogen to be partly mineral as stated above in (c) are suggested. Russet varieties of potatoes will resist the scab. If no manure is used, a formula carrying 4 percent nitrogen and 8 to 10 percent available phosphoric acid may be used.

(f) *Orchards.* Adequate tillage rather than fertilization is advised.

7. Manufacturers will sell in the main ammoniated superphosphates without potash. A few brands will carry one percent potash. The purchase of the latter at high prices for the potash is not advised. One percent rarely will be found to be worth while.

8. It is quite possible that under the peculiar conditions obtaining this year, ready mixed goods may sell in some instances at a less price than will the crude ingredients; that, in other words, home mixing will be done at a loss. Whenever possible farmers should secure quotations from several sources and buy cooperatively for cash.

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